ISOPLUS™ – Isolated Discrete Power Semiconductors

Objectives

This document outlines the specific product features of the ISOPLUS™ power semiconductor family. **Figure 1** displays some of the family's packages.

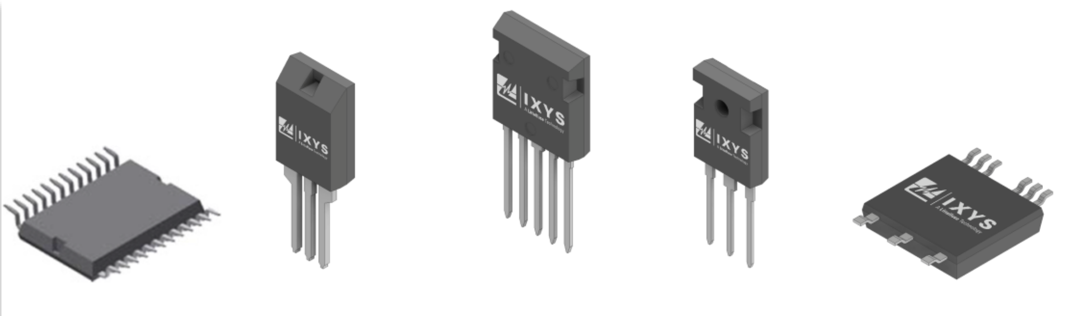

Figure 1. ISOPLUS™ Packages SMPD-DIL, TO-220, TO-247, I4-Pac and SMPD-B

Applications

- Industrial drives
- EV-charging
- White Goods
- Power Supplies
- Renewable energies

Target Audience

This document is intended for all power electronic developers confronted with hardware design and the challenge to build reliable systems with a focus on reasonable effort in component choice, layout, and thermal management.

Contact Information

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Table of Contents

List of Figures

List of Tables

1. Introduction

When using power semiconductors, there is usually a need to electrically isolate the devices from the heatsink, which could also be the equipment's chassis or housing. The main reasons for this are safety, the necessity to reduce electromagnetic interference by reducing stray capacitance between the chip and ground, and the desire to mount several devices onto the same heatsink.

Major penalties involve increased thermal resistances, complex assembly, and difficulty in testing of the insulation quality to meet different global safety standards. The most common method is to use an insulating material, sandwiched between the semiconductor device and the heatsink. Inherently, this increases the thermal resistance case-to-heatsink R_{thcs}.

Implementing discrete power semiconductors by adapting technologies from power modules led to the development of the ISOPLUS™ family. Here, a combination of insulating carriers with copper lead-frames and bond-wire interconnection enables an internal construction that achieves high insulation strength without sacrificing thermal performance.

This application note describes the major properties for the ISOPLUS™ Family.

2. Power Device

The ISOPLUS™ family today consists of a variety of different packages that all feature the same approach regarding internal construction and insulation. Being a power semiconductor platform, ISOPLUS™ family members are available in a wide range of technologies, topologies, and voltage classes.

3. Mechanical Construction

The key engineering achievement is the extension of the common copper lead frame by a copper-ceramic-copper laminate called Direct Copper Bonding or DCB. The ceramic itself can withstand an insulation voltage higher than 6 kV but for the ISOPLUS™-family, it is rated to 2.5 kV with respect to the external creepage and clearance distances of the package. The semiconductors are soldered to the structured DCB-frontside while the opposite side of the substrate is used for direct mounting to a heatsink. Interconnections of the chips is done using bond-wires. As an example, the cross section of the ISOPLUS™ SMPD package is displayed in **Figure 2**.

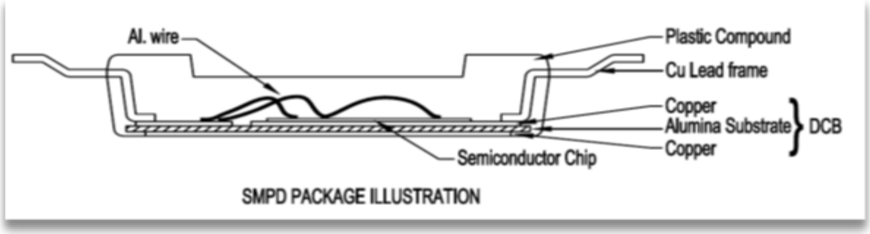


Figure 2. Cross-section of an ISOPLUS™ Device

The total number of layers from the heat source to the heatsink has been minimized to only one solder layer, the DCB ceramic and an external thermal grease. This results in a very low thermal resistance between chip and heatsink. Soldering the chip onto the DCB substrate that includes an insulator is a well-proven method for chip attachment and widely used in power semiconductor modules.

A common feature of all ISOPLUS™ devices is the hole-free package. In addition to the improvements in thermal performance, the area consumed by the mounting hole can now be utilized too.

4. Comparing the Thermal Situation

In contrast to traditional lead-frame-based packages with electrically active backsides, all members of the ISOPLUS™-family can be mounted to a heat sink by simply adding a high-performance Thermal Interface Material (TIM). Though these materials are available qualified as electrically non-conductive, this may not be misinterpreted as offering a qualified insulation strength. Applied to achieve a thin bond line between the power electronic component and the heat sink, a direct metal-to-metal contact cannot be excluded. From a thermal transfer point of view, maximizing this contact is beneficial as direct metal contacts provide the lowest possible thermal resistance. With non-insulated devices, this connection could lead to unwanted, potentially hazardous effects and needs to be prevented. As an isolator is needed between an active part and the heat sink, the chain of thermal resistances involved is unnecessarily prolonged.

Inherently, the thermal transfer capability of the connection is reduced.

Figure 3 sketches the setup as well as the chain of thermal resistances using an ISOPLUS™ device in combination with grease as thermal interface material.

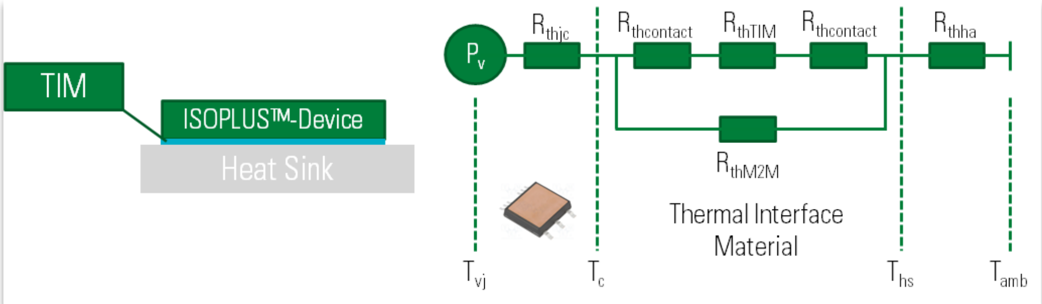


Figure 3. Thermal Model of an Isolated Package using Thermal Grease

The thermal resistance from junction to case R_{thjc} is defined by the solid construction of the power semiconductor. The path from the device's case to the heat sink's surface R_{thch} depends on the thermal interface in use. It's bulk resistance R_{thTIM} is typically given in the datasheet. Equally important is the material's capability to contact the surfaces to reduce the contact resistances $R_{thcontact}$ and allow a direct metal-to-metal path R_{thM2M}.

In comparison, a material with a guaranteed insulation strength changes the setup as inherently the metal-to-metal contact is eliminated. **Figure 4** depicts the difference, assuming a soft insulation layer like a silicone pad.

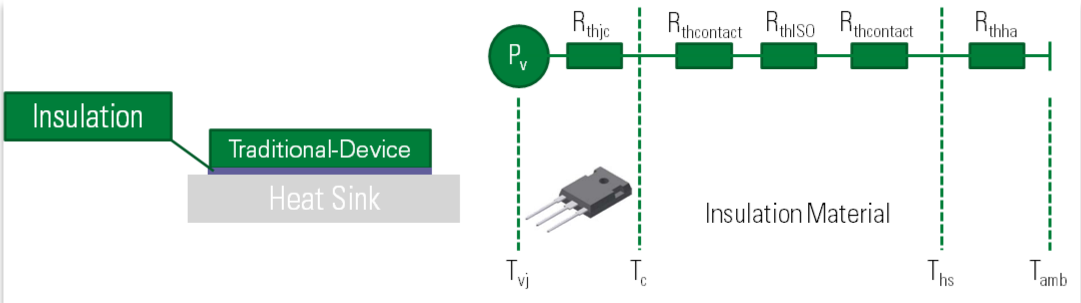


Figure 4. Thermal Model of a Non-insulated Package using a Silicone Pad

Without the metal-to-metal contact, a highly efficient part of the thermal chain is missing. Additionally, the contact resistance as well as the material's bulk resistance are higher than those of high-performance thermal greases, leading to lower thermal performance of the structure.

Replacing the soft material with a higher performance version like ceramic sheets further worsens the situation. These hard materials do not offer low contact resistances. A thermal grease needs to be used on both sides of such platelets, unnecessarily increasing the thermal resistance further, as seen in **Figure 5**.

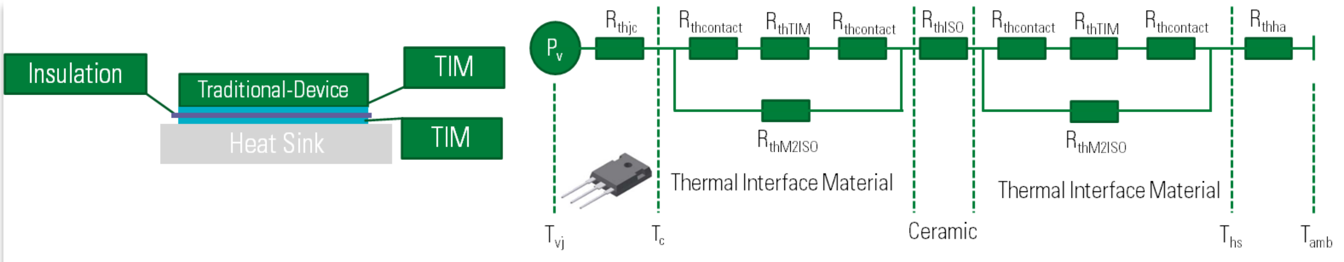


Figure 5. Thermal Model of a Non-insulated Package using a Ceramic Platelet and Thermal Grease

The improved thermal performance turns into higher electrical performance, as summarized in the diagram given in **Figure 6.**

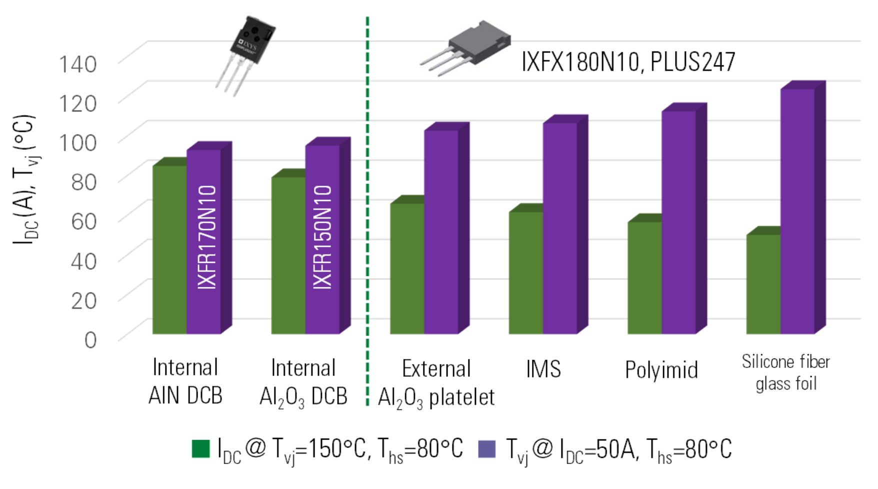


Figure 6. Comparing Electrical Performance of ISOPLUS™ 274 and PLUS247™ Devices

The PLUS247™ package is derived from the standard TO-247 and shares the same mechanical construction. To allow larger dies inside the package, no mounting hole is present in this package. Though the device used for this comparison holds the larger die inside, the DC-current achieved at maximum junction temperature is lower, compared to a smaller die in the ISOPLUS-setup.
Vice versa, at the same chip current, the chip temperature is lower within the ISOPLUS-device, leading to a gain in device lifetime.

5. Assembly Benefits

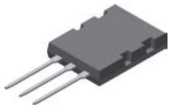
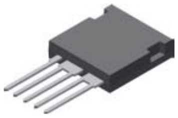
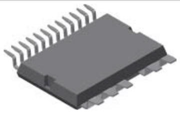
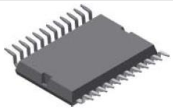
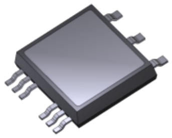
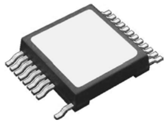
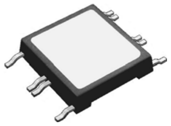
Traditional devices with an active backside require insulation as described in case all devices involved are mounted on the same heat sink. Instead, another approach consists of designs that group components with the same collector-potential to a common heat sink. This allows for improvement of the thermal situation but leads to other drawbacks. In a classical sixpack, this requires having four dedicated heat sinks that in turn need to remain insulated from each other. In more complex structures, this leads to an unnecessary number of heat sinks and inconvenient assembly processes.

Because of the insulated construction, multiple ISOPLUS™-devices can be mounted on a common heat sink. Correlating mounting suggestions can be found in the application note *Mounting and Cooling Solutions for SMPD Packages*.

6. Available Packages

Since the introduction of the ISOPLUS™ family back in 1998, additional packages have been added, as pictured in **Table 1**.

Table 1. The ISOPLUS Family Members

Overview on the ISOPLUS-Family		
		
ISOPLUS220™	ISOPLUS247™	ISOPLUS264™
		
ISOPLUS I4-PAC™	ISOPLUS I4-PAC™	ISOPLUS I4-PAC™
		
ISOPLUS264™	ISOPLUS-DIL™	ISOPLUS-DIL™
		
ISOPLUS-SMPD™-B	ISOPLUS-SMPD™-X	ISOPLUS-SMPD™-Y

In each package, a variety of technologies, topologies, and voltage classes is available. The most recent information can be found in the Power Semiconductor Product Catalog. The file can be downloaded from the Technical Resources page on the Littelfuse website.

Revision	Date	Major work done
1.0	2001	IXYS AN0025 on the ISOPLUS^{TM}
21.09a	2021	Reworked and updated

For additional information please visit www.Littelfuse.com/powersemi

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