Application Note AN 2009-07
V1.3 August 2013

MIPAQ™ serve

Module with adapted driver electronics

Edition 2013-08-16
Published by
Infineon Technologies AG
59568 Warstein, Germany

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AN 2009-07

Revision History: date (13-08-16), V1.3

Previous Version: V1.2

Subjects: Chapter 5 updated, minor changes

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1 The MIPAQ™ Family – A brief Introduction

MIPAQ™ is a functional product family and dedicated to useful integration of electronics into power modules. The MIPAQ™ family has been developed in order to offer **M**odules **I**ntegrating **P**ower, **A**pplication and **Q**uality. **I**t is a functional product family within **I**nfineon's **I**GBT modules portfolio. The combination of an IGBT module and integrated sensing and driving electronics leads to an optimized solution in mastering the challenge of designing powerful and compact inverters for low and medium power. It eases the cost situation on the one hand and contributes to energy saving on the other hand. Thus, it improves the profitability and protects our environment at the same time.

The MIPAQ™ family today has a hierarchical structure of three product types:

- MIPAQ™ base – a module with integrated current sensing shunts
- MIPAQ™ sense – a module with integrated, fully digital current measurement
- MIPAQ™ serve – a module with adapted driver electronics and temperature measurement

This document focuses on the application and the special features of the MIPAQ™ serve.

Prior to operating and handling the module, please carefully read and completely understand this application note!

1.1 Product Range

MIPAQ™ serve provides an IGBT sixpack, a full set of six IGBT-drivers along with digital temperature measurement. The modules utilize in the well-proven EconoPACK™ 4 housing with 100A, 150A and 200A nominal current at 1200V blocking voltage.

1.2 Scope of Applications

Equipped with a sophisticated driver to allow high precision timing, the MIPAQ™ serve is suitable for various applications like general purpose drives, UPS, welding, air conditioning systems, servo drives, auxiliary inverters and the utilization in renewable energy systems.

1.3 MIPAQ™ notation

The notation of MIPAQ™ family modules follows the Infineon rules for standard industrial modules. The capital "I" as a first digit denotes that the module is part of the MIPAQ™ family. The designation for a module is explained in the table below:

Designation Example	Information on		Explanation
IFS 200 V 12 P T4		**I**	Module belongs to the MIPAQ™ family
	Configuration	FZ	Single Switch
		FF	Half Bridge
		FS	Sixpack
	Rated Chip Current in A	**200**	
	Level of Integration	B	MIPAQ™ base with integrated shunts
		S	MIPAQ™ sense with integrated digital current measurement
		V	MIPAQ™ serve with adapted driver electronic and digital temperature measurement
	Voltage Class	**12**	Maximum blocking voltage in 100V
	Package used	N1…3	Econo1 to Econo3
		P	EconoPACK4
		U1…3	Smart1 to Smart3
	Chip Technology	**T4**	Low-Power IGBT 4
		E4	Medium-Power IGBT 4
		P4	High-Power IGBT 4

2 Mechanical Features

Figure 1 shows the MIPAQ™ serve with its most obvious mechanical features:

Figure 1 MIPAQ™ serve in the established EconoPACK™ 4 housing

3 Schematic – Overview

In Figure 2 an overview of the electric components within the MIPAQ™ serve is depicted:

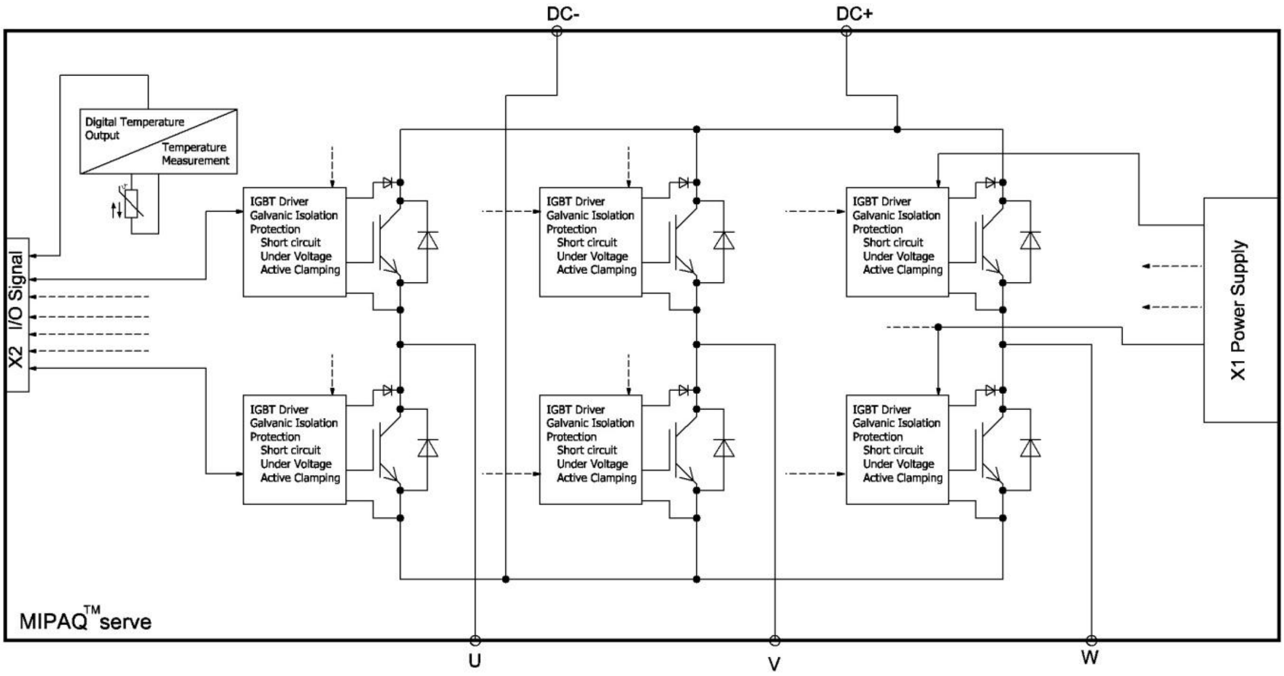

Figure 2 Overview on the electric components within the MIPAQ™ serve

The included driver is based on Infineon's Coreless Transformer Technology and provides all features known from the single IGBT-Driver 1ED020I12-F. For a detailed description of the driver-IC please refer to the according Datasheet.

4 Adapted Driver Electronics

The electronics included in the MIPAQ™ serve is optimized to properly drive and protect the IGBTs. The following sections describe the special features provided by the driver.

4.1 Necessary Power Supply

To properly supply the drivers with power it is necessary to have four voltage sources that are galvanically separated. The isolation between these voltages has to be sufficient for 1200V-applications. Switch mode power supplies like the one shown in Figure 3 can be used to provide bipolar voltages of +16V/GND/-8V as recommended in the MIPAQ™ datasheet as typical values.

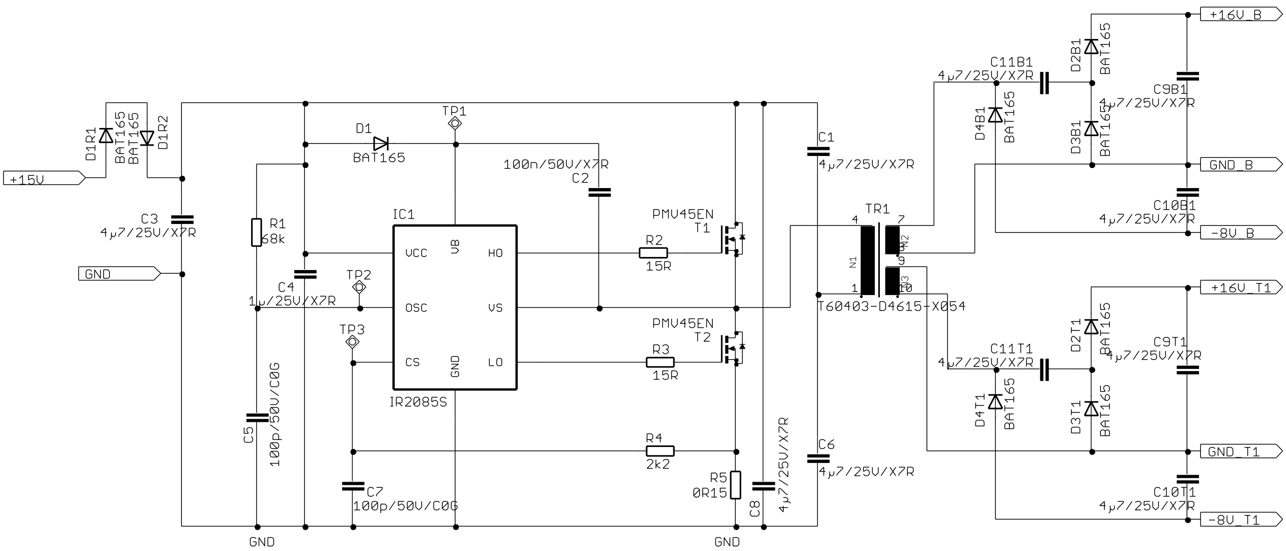

Figure 3 Example for a switch mode power supply

Slight differences especially in the transformer and tolerances among the used components will lead to variations of the output voltages as the depicted design only provides a non regulated supply. Care should be taken to minimize these deviations of the output voltages if several supplies are designed in this manner.

The power consumption of the drivers varies with temperature and switching frequency. To properly operate the module under all specified conditions the supply has to be designed for the worst case, represented by 20kHz switching frequency at 85°C base plate temperature. Under these conditions, the supplies for the high-side drivers have to be capable to provide a maximum output current of 40mA. At the low-side the supply has to provide three drivers and the temperature measurement with power; consequently, it has to be capable to drive a maximum current of 120mA.

4.1.1 Driver Supply Connector

In Figure 1 the mechanical features of the MIPAQ™ serve are mentioned, showing the pluggable connector for the IGBT-driver power supply. To ensure availability all over the world, a 2-row 22-pin header of the Molex Micro-Fit series was chosen for the MIPAQ™ serve with a pin assignment as presented in Figure 4.

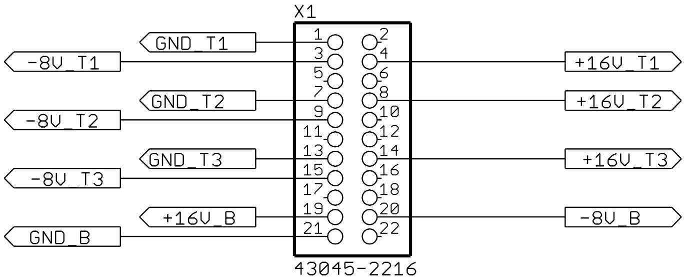

Figure 4 Pin assignment of the driver supply connector X1

To achieve the clearance distances mandatory for 1200V-modules, one row of pins between two supply voltages is intentionally left blank thus increasing the distance between active pins.

The header used mates to Molex receptacle-type 0430252200. Crimp terminals of Molex-type 0430300003 have to be used to tailor the connecting wires to match individual needs. A symbolic representation of the receptacle and terminal are depicted in Figure 5.

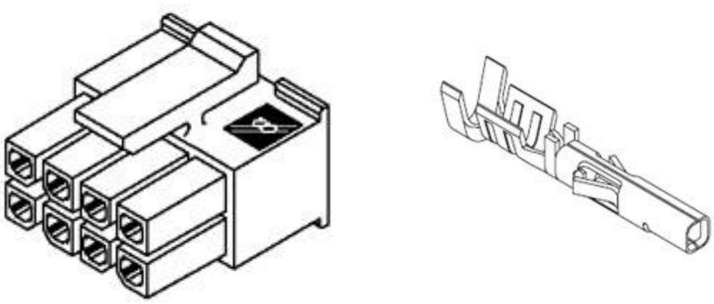

Figure 5 Molex receptacle and appropriate terminal

The crimping can be done manually if desired. An according crimping tool is available from Molex, order number 0638190000.

4.2 Logic Signal Connections

Depending on the isolation needs, there are two possibilities to connect the MIPAQ™ serve to a given control electronics. As basic isolation is already included a direct connection between control and power electronics is possible if this level of isolation is sufficient.

To achieve reinforced isolation, a second basic isolation barrier in series to the one implemented within the module is needed. This barrier can be built using any means of isolation available. A traditional approach can be made by utilizing optoelectronic couplers.

Figure 6 depicts an example using magnetic couplers to add basic isolation to the gate signal paths. In principle, this solution can also be used for the error signals provided by the drivers.

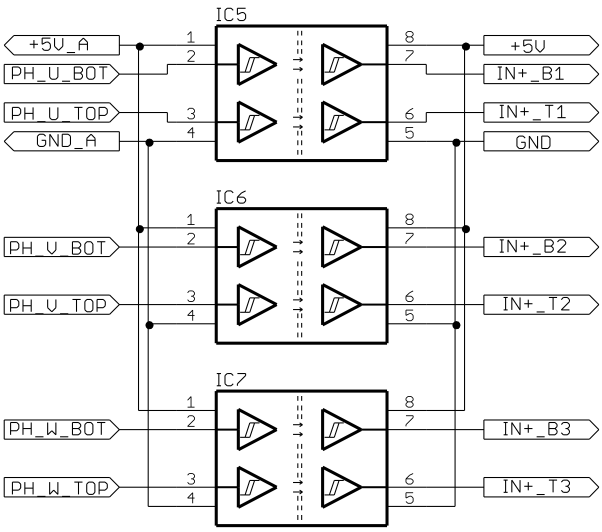

Figure 6 Additional basic isolation for gate-signals

4.2.1 Logic Signal Connector

Connecting the signals and the necessary 5V-supply to the module is done using a Molex Milli-Grid connector in 22-pin 2-row header configuration with a pin assignment as visible in Figure 7.

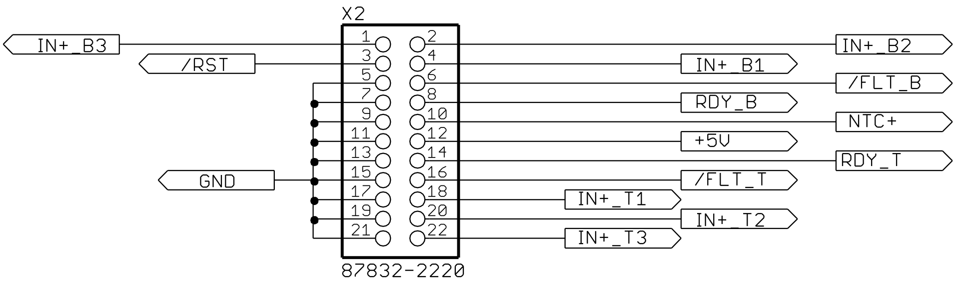

Figure 7 Pin assignment for X2: 5V-supply and logic signals

All necessary pull-up resistors are included in the MIPAQ™ serve, no further external elements need to be added. B1 to B3 refers to the bottom-side transistors, T1 to T3 to the top-side. Reset /RST and fault-signals /FLT_B, /FLT_T are low-active. The logic supply's +5V are referenced to the according control electronic. Positive logic is utilized for the gate signals.

The control signals for the gate driver are 5V-cmos compatible and considered "low" at voltages up to 1.5V and "high" at levels 3.5V and above.

The 5V-supply has to be provided within a tolerance of ±0.5V, the module takes a maximum current of 50mA out of the 5V-source.

The header integrated into the MIPAQ™ serve mates to a receptacle type 0875682293 for ribbon wire. Optionally a strain relief with order number 0875691022 is available. Both parts are shown in Figure 8.

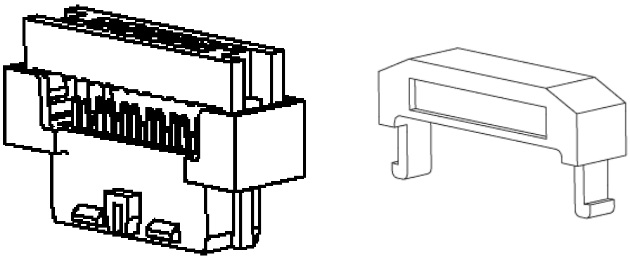

Figure 8 Milli-Grid receptacle and strain relief

Due to the different geometries the two connectors can not be swapped. Additionally both connectors are locked to protect them from vibration. Furthermore, the receptacles feature keys making it impossible to mount them in the wrong direction.

5 Connecting wires

The connections to power- and logic side have to be tailor made regarding the applicational needs. Due to the wired connection, the MIPAQ™ serve eases the design of the interconnection between control electronics and power section. Though it is recommended to keep the connecting wires as short as possible a maximum length not exceeding 3 meters is possible. It has to be ensured that the connections to power- and logic side are clearly separated from the high current paths to avoid cross-conduction and malfunctions of the electronics.

The power connection is based on single wires with crimped terminals. A conductor area of 0.5mm² is recommended. To achieve proper levels of isolation further isolation layers e.g. tubes can be used.

To connect the logic signals, a ribbon cable with 22 conductors is necessary. As the connector features 2mm pin-to-pin spacing, the cable has to provide a 1mm pitch.

Examples for tailor-made wires are given in Figure 9:

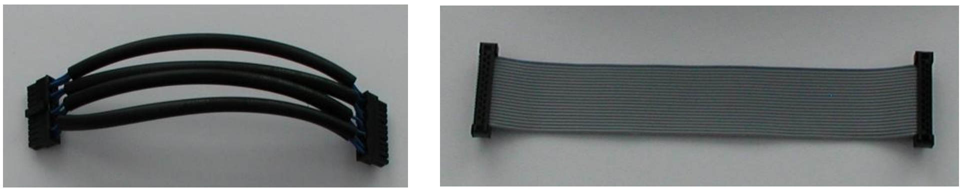

Figure 9 Wires for power and logic connection

6 Implemented Protection Features

The MIPAQ™ serve is equipped with the 1ED020I12-F driver-IC. The relevant protection features implemented within this driver concern undervoltage lockout and short circuit detection. Undervoltage lockout refers to the supply voltages of the driver. Below the threshold voltage the driver provides an error signal and keeps the according IGBT turned off. These error-signals are logically or-connected to provide a dedicated READY in two groups separately showing the condition of the three top-side drivers as one group and the low-side drivers as the second group. The driver's outputs only become active if all drivers are properly supplied.

The short circuit protection is based on desaturation voltage detection. If a short circuit appears, the collector-emitter-voltage of the IGBT rises rapidly. At a level of about 9V the DESAT-detection of the gate driver is activated turning off the related IGBT.

To prevent accidental turn-off a blanking time of approximately 6µs is implemented. This blanking time is necessary to prevent the desaturation detection from being triggered if capacitive loads such as long wires need to be handled. The specified short circuit withstand time of IGBT4 is 10µs and the IGBT is turned of well within this limit if short circuit is detected. A typical short circuit turn-off is shown in Figure 10.

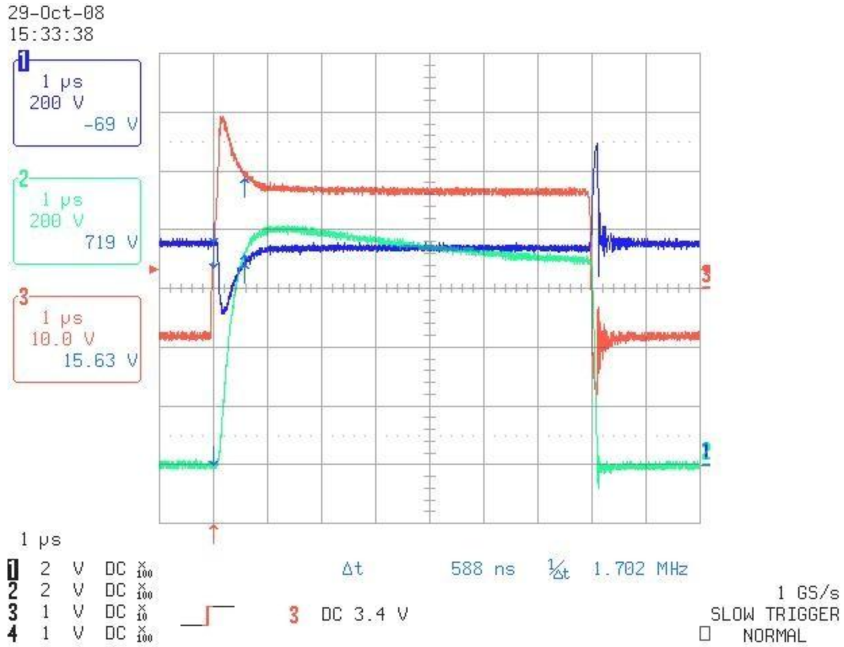

Figure 10 Typical short circuit turn-off, U_{DC}=750V, I_{max}~800A, t_{sc}~7µs
green trace: Collector current @ 200A/div
blue trace: Collector-Emitter voltage @ 200V/div
red trace: Gate-Emitter voltage @ 10V/div

The short circuit protection is specified to properly work with up to 850V DC-Link voltage as long as the overall DC-Link stray inductance is kept below 100nH including the module.

7 Digital Temperature Measurement

Based on the internal NTC a temperature measurement is set up. The digital information about the baseplate temperature is coded in the output frequency. Counting pulses of the temperature signal for a determined time includes the information on the temperature; the relation is hinted out in Figure 11:

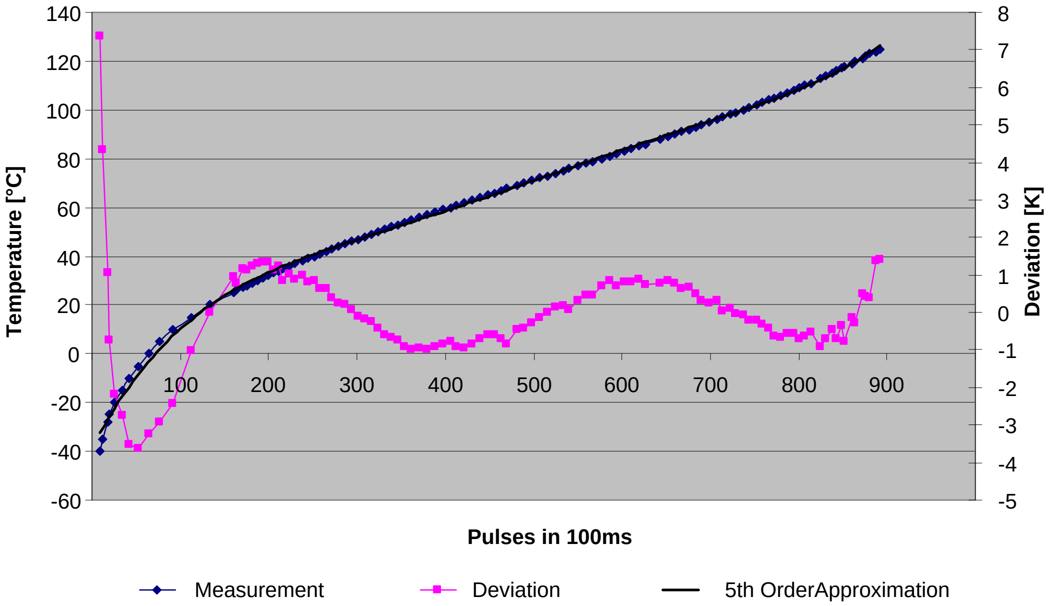

Figure 11 Relation between temperature and pulses counted

Pulses were counted for 100ms. The graph also includes a 5th order approximation to the measurement done; the temperature *T* can be calculated from *x* pulses in 100ms to be:

$$T\,[°C] = 2{,}2130E\text{-}12x^5 - 5{,}6476E\text{-}09x^4 + 5{,}5375E\text{-}06x^3 - 2{,}5924E\text{-}03x^2 + 6{,}9881E\text{-}01x - 38{,}703$$

The added purple line shows the absolute difference between this approximation and the true temperature that was measured as well. This approach achieves an absolute accuracy within ±1K for the temperature range of interest.

Of course several other fittings or multiple polygonal linearizations' can be done. As the NTC used for the measurement has a tolerance on its own, it is recommended to calibrate the measurement at a well defined temperature to achieve the most reliable and accurate reading.

As for the all logic signals, the temperature signal as well is galvanically isolated from the power electronic section using Infineon's Coreless Transformer Technology to form a basic isolation barrier.

The electronics used to read out the NTC along with the isolation barrier involved has to be properly supplied to operate. Internally, the supply is taken from the low-side driver supply connected to X1.19 and X1.21. To test the temperature measurement, at least the 5V logic supply at X2.12 along with the low-side supply at X1.19/21 has to be available to generate the temperature signal NTC+ at X2.10.

8 Handling and Mounting

“MIPAQ™” does not refer to a certain package but to functionality. Mounting and handling different modules however is related to the package utilized. The following sections interlink the Application Notes on how to mount and handle different packages.

For any given module it is recommended to apply thermal grease to form a proper thermal interface to the heatsink. As described in the Application Note AN 2006-02 *Application of screen print templates to paste thermal grease within IGBT modules* it is recommended to utilize a process that achieves sufficiently reproducible results. The document can be downloaded at Infineon's Document Database

8.1 MIPAQ™ serve in EconoPACK™ 4-Packages

For mounting and handling instructions regarding EconoPACK™ 4-Type modules please refer to the application note AN 2010-06 *EconoPACK™4 Product Family - Mounting instructions / Application Note*, please use the link above to go to Infineon’s Document Database.