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MIPAQ™ base

Making use of Modules with integrated
Shunts



Industrial Power

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1 The MIPAQ™ Family – A brief Introduction

MIPAQ™ is a new functional product family and dedicated to useful integration of electronics into power modules. The MIPAQ™ family was developed in order to offer Modules Integrating Power, Application and Quality. It is a functional product family within Infineon's IGBT modules portfolio. The combination of an IGBT module and the integration of sensing and driving electronics leads to an optimized solution in mastering the challenge of designing powerful and compact inverters for low and medium power at low costs, contributing to energy savings to improve profitability and protect 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™ base.

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

1.1 Product Range

MIPAQ™ base provides an IGBT sixpack plus current sense shunts inside. The modules come in sixpack configuration with NTC and are available in the well-proven EconoPACK™ 3 housing with 75A, 100A and even 150A nominal current at 1200V blocking voltage. Two versions of IGBT⁴ are available depending on the applicational needs. IGBT⁴ T4 resembles the fast switching version for sophisticated designs with low stray inductive setup while IGBT⁴ E4 with its increased tail currents allows for softer switching in applications where larger stray inductances can not be avoided.

1.2 Scope of Applications

The current sensing shunts inside the MIPAQ™ base are located in the output lines to measure the true application current under all conditions. The MIPAQ™ base therefore is an excellent choice for general purpose as well as servo-drives. It will work in applications like uninterruptable power supplies (UPS) as well as solar inverters and low power machinery like pumps, fans or air conditioning systems. The accurate measurement and the excellent stability of the sensors make the MIPAQ™ base a good candidate for high performance drives like tooling machines and supports the implementation of highly sophisticated regulation algorithms like field oriented control (FOC) or direct torque control (DTC).

Measuring three line currents makes the MIPAQ™ base the perfect solution for active front end (AFE) designs utilizing B39-variants with enlarged diode dies.

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 Table 1

Designation Example	Information on		Explanation
IFS 150 B 12 N3 T4	Configuration	FZ	Single Switch
		FF	Half Bridge
		FS	Sixpack
	Rated Chip Current in A	150	
	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

Table 1 Overview on the MIPAQ™ notation

2 Electrical Charakteristics

From optical point of view, the MIAPQ™ base as displayed in Figure 1 appears to be a plain sixpack built into a standardized EconoPACK™ 3 housing:

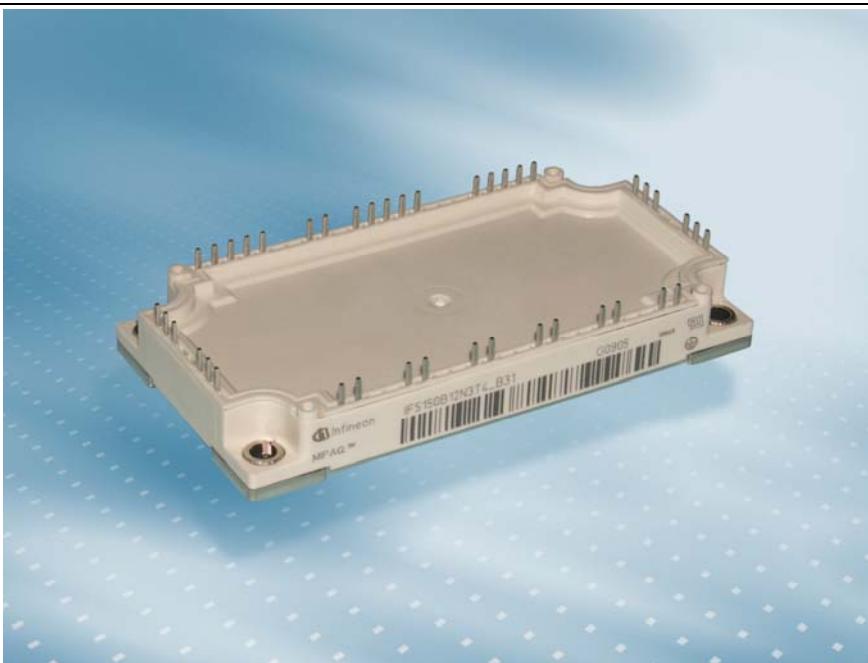


Figure 1 MIAPQ™ base in the established EconoPACK™ 3 housing

Besides the type designation, the slightly different pinning compared to the standard module is the only visible difference. The additional pins right next to the power terminals belong to the shunts and represent the sense connections.

2.1 Current Sense Shunts

Though many different systems can be used to measure electric current, shunts have proven to resemble the best possible sensor when it comes to integrating current measurement into power electronic devices. Among the reasons that lead to this setup are:

- Shunts provide the mandatory operating temperature range and easily withstand the high temperatures inside of power electronic modules
- Shunts have a proper geometric size for the integration
- The shunt that was especially designed for this kind of modules comes with outstanding thermal capabilities, excellent thermal transfer to the module's baseplate and high cycling capabilities towards power- and thermal cycling.
- Bearing in mind that a precise reading is necessary across a wide temperature range, the material utilized provides excellent linearity in the temperature range common to power electronic modules.
- Shunts do not show effects like offset, hysteresis or distortion after exceeding the rated current limits e.g. during short circuit
- Shunts as sensors do not inherently limit the bandwidth of the measurement

2.2 Internal Schematic

To provide a current measurement that captures the application's current in all points of operation, it is essential to choose a position for the sensor in line with the application as shown in Figure 2:

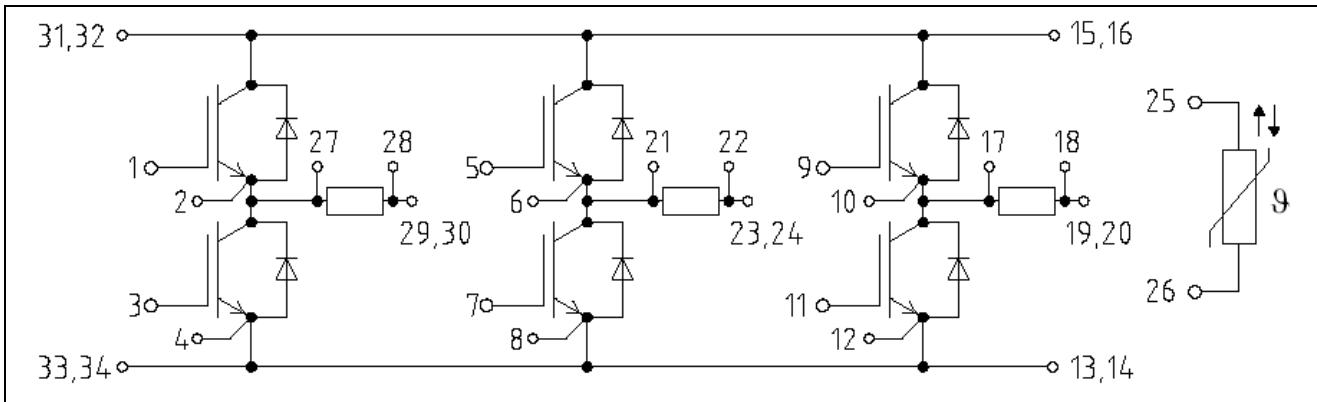


Figure 2 Schematic of the IFS100B12N3T4_B31

Compared to a solution with open emitter connections and shunts in series to the emitter paths, this configuration includes several advantages:

- There is no influence to the Gate-Emitter voltage of the low-side IGBT
- Even the minute stray inductance of the shunt itself would influence the switching behavior if mounted in series to the emitter; however, it is of no influence if connected in series to the application.
- A freewheeling current can be measured in both upper and lower half of the sixpack.

2.3 The Shunt's properties

In theory, the current to be measured is proportional to the voltage drop across the shunt. Practically, the temperature inside the module influences the shunt's resistance as both the shunt and the silicon inside the power electronic contribute to increase the temperature level. To get an accurate and precise reading the shunt's resistance has to remain constant with regard to temperature including the whole possible range of operating conditions. Within the MIPAQ™ base this is achieved using materials with very low temperature dependencies. As depicted in Figure 3, the linearity of the shunt included is excellent over a wide range of temperatures:

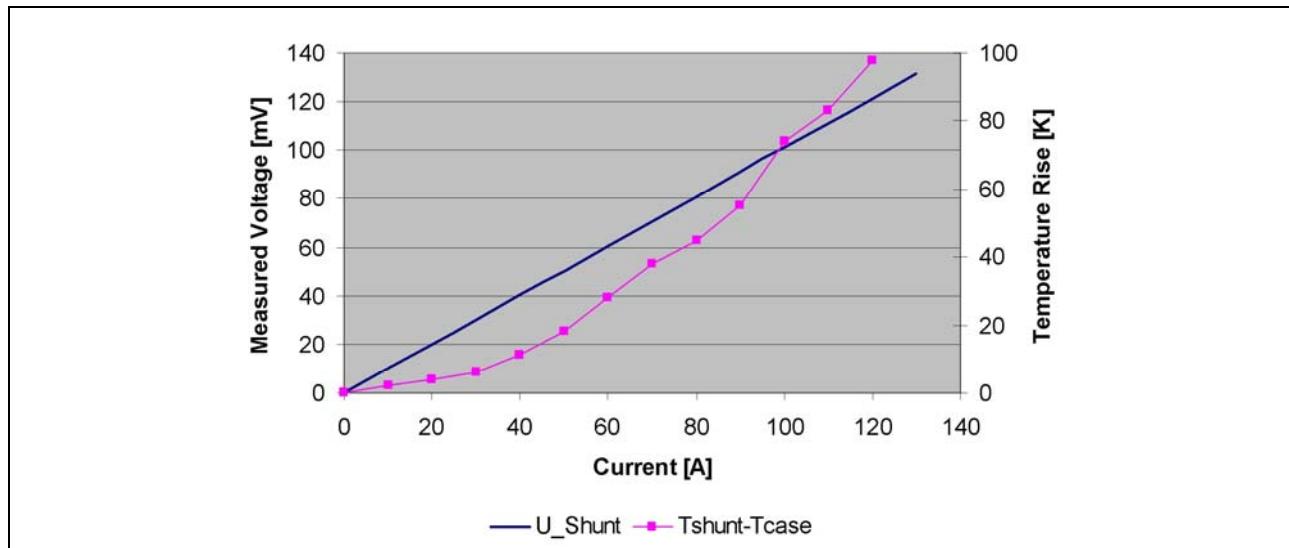


Figure 3 Shunt temperature development as a function of forward current. DUT: Shunt 1mΩ

An additional temperature rise may appear as a consequence of the baseplate heating up during operation. This too will add to the shunt's temperature. However the influence is marginal as hinted out in Figure 4:

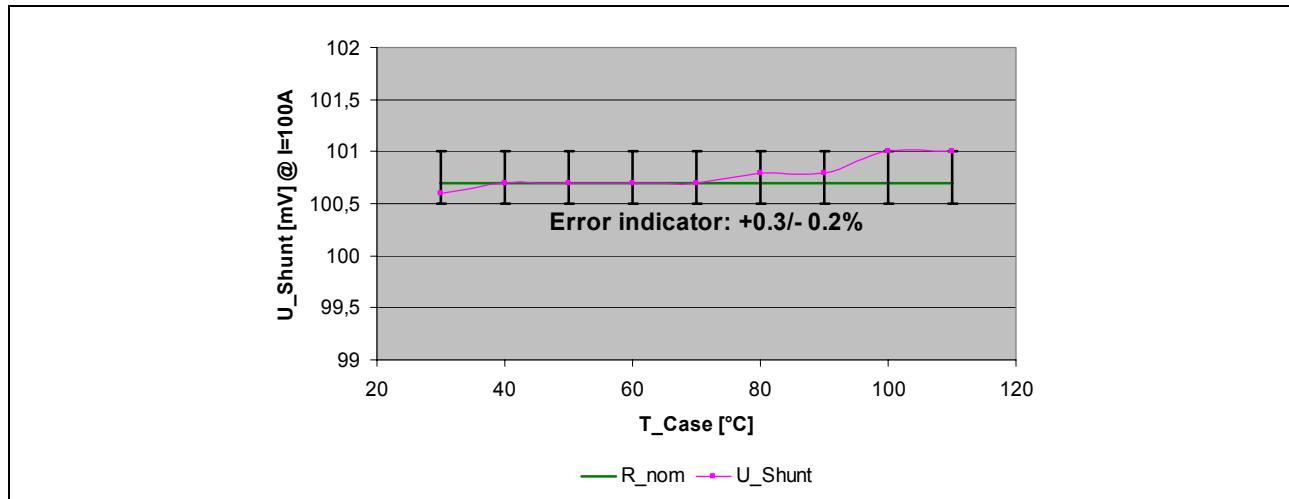


Figure 4 Shunt voltage as a function of baseplate temperature. DUT: Shunt 1mΩ, I=100A

2.4 Captureing the shunt's voltage

The shunt is connected in series to the application. This inherently means that it is connected to high voltages referred to either side of the DC-link. To properly capture the shunt's voltage, a device with differential input is recommended that has its reference set to the upper IGBT's emitter potential. An overview is given in Figure 5:

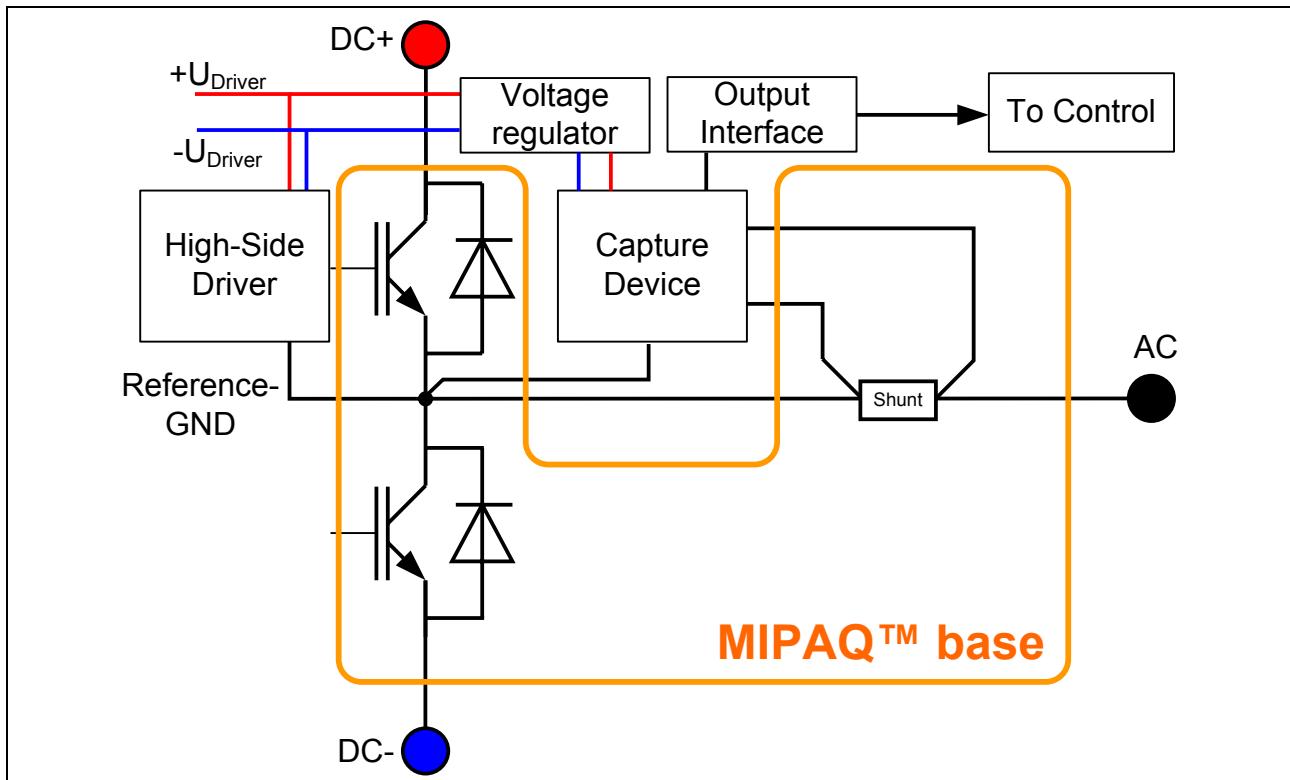


Figure 5 Capturing the Shunt's voltage

The components visible in the functional diagram may be optional depending on the method to connect the control electronics.

Voltage Regulator

As the driver supply is also referenced to the IGBT's emitter potential, the supply for the capture-device can be derived from this source as well. Depending on the voltage levels and the design, a simple line regulation can be sufficient. If the supply for the capture device is compatible to the IGBT-driver supply, a voltage regulator is obsolete.

Capture Device

Any device used to capture the shunt's voltage has to be capable to handle bidirectional voltages at its inputs. The input voltage range has to be sufficient in respect to the highest possible shunt voltage. The worst case of course is a short circuit condition at the module's output lines. Given the recommended values in the datasheet are not exceeded the IGBT will limit the short circuit current.

This leads to maximum voltages across the shunts that can be evaluated from the short circuit current level and the shunt's value. All necessary information is included in the according datasheets.

In general, there are two methods to implement the capture device:

- Operational Amplifier to shift the measured voltage to a level suitable for further analysis
- High-side A/D converter with suitable low voltage inputs

To reduce the electromagnetic interference, care should be taken, that the loop created by the connection from the shunt to the capture-device is minimized.

Output Interface

Both solutions to form a capture device still provide an output signal referenced to the high-side IGBT's emitter potential. This results in the necessity to have an interface to fulfill several tasks:

1. Shift the output signal to a level referenced to the control electronic's ground
2. Transform the signal generated by the capture device into a signal or protocol compatible to the control electronics
3. Provide a proper level of galvanic isolation between control- and power electronics

Depending on the capture device the interface or at least parts of it may already be included. There are for example linear optoelectronics providing the functionality mentioned above.

If High-Side A/D-conversion is used, galvanic isolation for the digital signal has to be added. It depends on the developers preferences to either separate the digital signal itself or have a protocol set up that is transported across an isolating barrier.

3 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 2006-002 *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](#)

3.1 MIPAQ base in Econo3-Packages

For mounting and handling instructions regarding Econo-Type modules please refer to the Application note AN2002-04 *Econo Modules: Mechanical Attributes for new FS und FP Econo-series* , please use the link above to go to Infineon's Document Database.