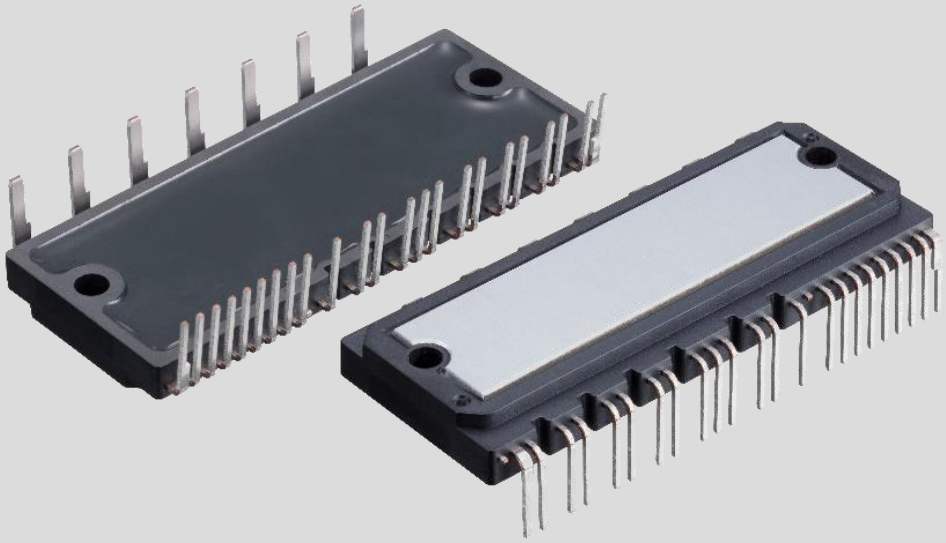
Fuji Electric
Innovating Energy Technology



Small IPM (Intelligent Power Module)
P642 Series
6MBP**XT*065-50

Application Manual

April 2024

Fuji Electric Co., Ltd.

MT6M15234 c

Cautions

This Instruction contains the product specifications, characteristics, data, materials, and structures as of April 2024. The contents are subject to change without notice for specification changes or other reason. When using a product listed in this Instruction be sure to obtain the latest specifications.

The application examples in this note show the typical examples of using Fuji products and this note shall neither assure to enforce the industrial property including some other rights nor grant the license.

Although Fuji Electric Co., Ltd. continually strives to enhance product quality and reliability, a small percentage of semiconductor products may become faulty. When using Fuji Electric semiconductor products in your equipment, be sure to take adequate safety measures such as redundant, flame-retardant and fail-safe design in order to prevent a semiconductor product failure from leading to a physical injury, property damage or other problems.

The products described in this application manual are manufactured with the intention of being used in the following industrial electronic and electrical devices that require normal reliability.

- Compressor motor inverter
- Fan motor inverter for room air conditioner
- Compressor motor inverter for heat pump applications, etc.

If you need to use a semiconductor product in this application note for equipment requiring higher reliability than normal, such as listed below, be sure to contact Fuji Electric Co., Ltd. to obtain prior approval. When using these products, take adequate safety measures such as a backup system to prevent the equipment from malfunctioning when a Fuji Electric's product incorporated in the equipment becomes faulty.

- Transportation equipment (mounted on vehicles and ships)
- Trunk communications equipment
- Traffic-signal control equipment
- Gas leakage detectors with an auto-shutoff function
- Disaster prevention / security equipment
- Safety devices, etc.

Do not use a product in this application note for equipment requiring extremely high reliability such as:

- Space equipment
- Airborne equipment
- Atomic control equipment
- Submarine relaying equipment
- Medical equipment

If you have any question about any portion of this application note, ask Fuji Electric Co., Ltd. or its sales agencies. Neither Fuji Electric Co., Ltd. nor its agencies shall be liable for any injury or damage caused by any use of the products not in accordance with instructions set forth herein.

Chapter 2 Description of Terminal Symbols and Terminology

1. Description of Terminal Symbols

Table 2-1 and Table 2-2 describe the terminal symbols and terminology, respectively.

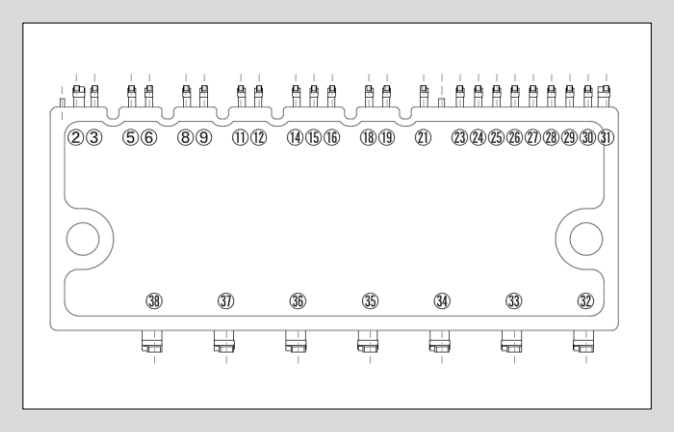


Fig.2-1 Terminals number

Table 2-1 Description of terminal symbols

Terminal No.	Terminal Name	Terminal Description	Terminal No.	Terminal Name	Terminal Description
2	IN(HU)	Signal Input for High-side U-phase	24	COM	Low-side Control Power Supply GND
3	VCCH(U)	High-side Control Power Supply for U-phase	25	TEMP	Temperature Sensor Output
5	VB(U)	High-side Bias Voltage for U-phase	26	IS	Overcurrent Sensing Voltage Input
6	VS(U)	High-side Bias Voltage for U-phase GND	27	CFO	Fault Output Pulse Width Setting
8	IN(HV)	Signal Input for High-side V-phase	28	VFO	Fault Output
9	VCCH(V)	High-side Control Power Supply for V-phase	29	IN(LU)	Signal Input for Low-side U-phase
11	VB(V)	High-side Bias Voltage for V-phase	30	IN(LV)	Signal Input for Low-side V-phase
12	VS(V)	High-side Bias Voltage for V-phase GND	31	IN(LW)	Signal Input for Low-side W-phase
14	IN(HW)	Signal Input for High-side W-phase	32	N(W)	Negative Bus Voltage Input for W-phase
15	VCCH(W)	High-side Control Power Supply for W-phase	33	N(V)	Negative Bus Voltage Input for V-phase
16	COM	High-side Control Power Supply GND	34	N(U)	Negative Bus Voltage Input for U-phase
18	VB(W)	High-side Bias Voltage for W-phase	35	W	W-phase Output
19	VS(W)	High-side Bias Voltage for W-phase GND	36	V	V-phase Output
21	VSC	Low-side Sense Current Detection	37	U	U-phase Output
23	VCCL	Low-side Control Power Supply	38	P	Positive Bus Voltage Input

2. Description of Terminology

Table 2-2 Description of terminology (Inverter Block)

Item	Symbol	Description
Zero Gate Voltage Collector Current	I_{CE}	Leakage current when a specified voltage is applied between the collector and emitter of an IGBT with all input signals L (= 0V).
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$ (terminal)	Collector-emitter voltage at a specified collector current when only the input signal of the element under measurement is H (= 5V) and the inputs of all other elements are L (= 0V).
Forward Voltage	V_F	Forward voltage at a specified forward current with all input signals L (= 0V).
Turn-on Time	t_{on}	The time from when the input signal voltage level exceeds the threshold value until the collector current rises to 90% of the rated current. See Fig. 2-2 for details.
Turn-on Delay Time	$t_{d(on)}$	The time from when the input signal voltage level exceeds the threshold value until the collector current rises to 10% of the rated current. See Fig. 2-2 for details.
Turn-on Rise Time	t_r	The time for the collector current to rise from 10% to 90% of the rated current when the IGBT is turned on. See Fig. 2-2 for details.
V_{CE}-I_C Cross Time of Turn-on	$t_{c(on)}$	The time from when the collector current reaches 10% of the rated current until the V_{CE} voltage fall to 10% of the rated voltage when the IGBT is turned on. See Fig. 2-2 for details.
Turn-off Time	t_{off}	The time from when the input signal voltage level falls below the threshold value until the collector current falls to 10% of the rated current. See Fig. 2-2 for details.
Turn-off Delay Time	$t_{d(off)}$	The time from when the input signal voltage level falls below the threshold value until the collector current falls to 90% of the rated current. See Fig. 2-2 for details.
Turn-off Fall Time	t_f	The time for the collector current to fall from 90% to 10% of the rated current when the IGBT is turned off. See Fig. 2-2 for details.
V_{CE}-I_C Cross Time of Turn-off	$t_{c(off)}$	The time from when the V_{CE} voltage reaches 10% of the rated voltage until the collector current fall to 10% of the rated current when the IGBT is turned off. See Fig. 2-2 for details.
Reverse Recovery Time	t_{rr}	The time required to reduce the reverse recovery current of FWD to zero. See Fig. 2-2 for details.

Table 2-3 Description of terminology (Control Circuit Block)

Item	Symbol	Description
Circuit Current of Low-side	I_{CCL}	Consumption current between VCCL and COM.
Circuit Current of High-side	I_{CCH}	Consumption current between VCCH(U, V, W) and COM (for each phase).
Circuit current of Bootstrap circuit	I_{CCHB}	Consumption current between VB(U)-VS(U), VB(V)-VS(V), and VB(W)-VS(W) (for each phase).
Input Signal Threshold Voltage	$V_{th(on)}$	Input signal threshold voltage that turns on the IGBT.*1
	$V_{th(off)}$	Input signal threshold voltage that turns off the IGBT.*1

Table 2-3 Description of terminology (Control Circuit Block) (Continued)

Item	Symbol	Description
Input Signal Threshold Voltage	$V_{th(on)}$	Input signal threshold voltage that turns on the IGBT.*1
	$V_{th(off)}$	Input signal threshold voltage that turns off the IGBT.*1
Input Signal Threshold Hysteresis Voltage	$V_{th(hys)}$	Hysteresis voltage between $V_{th(on)}$ and $V_{th(off)}$.*1
Operational Input Pulse Width of Turn-on	$t_{IN(on)}$	Control signal pulse width required to turn-on the IGBT. Refer to Chapter 3.4 for details.
Operational Input Pulse Width of Turn-off	$t_{IN(off)}$	Control signal pulse width required to turn-off the IGBT. Refer to Chapter 3.4 for details.
Input Current	I_{IN}	Current flowing between IN(HU,HV,HW,LU,LV,LW) and COM.
Input Pull-down Resistance	R_{IN}	Resistance of built-in resistor between IN(HU,HV,HW,LU,LV,LW) and COM. (for each phase).
Fault Output Voltage	$V_{FO(H)}$	VFO output voltage during normal operation (low-side protection function is not activated). External pull-up resistor = 10kΩ.
	$V_{FO(L)}$	VFO output voltage when low-side protection function is activated.
Fault Output Pulse Width	t_{FO}	The period during which VFO continues to output after low-side protection function is activated. Refer to Chapter 3.6 for details.
Overcurrent Protection Voltage Level	$V_{IS(ref)}$	Overcurrent protection threshold voltage of IS. Refer to Chapter 3.5 for details.
Overcurrent Protection Delay Time	$t_{d\ (IS)}$	The time from overcurrent condition is detected until the collector current falls below 50% of rating. Refer to Chapter 3.5 for details.
Overcurrent Trip Level	I_{oc}	The current value that can be detected when a specified sense resistor Rsc is connected between VSC and COM without connecting external shunt resistors to N(U), N(V), and N(W).
Output Voltage of Temperature Sensor	$V_{(temp)}$	TEMP output voltage. Applied to temperature sensor output model. Refer to Fig. 2-3 and Chapter 3.7 for details.
Pull down Resistance of TEMP terminal	$R_{(temp)}$	Resistance value at which the temperature characteristic of TEMP output voltage becomes linear below room temperature.
Overheating Protection Temperature	T_{OH}	Tripping temperature of overheating protection by LVIC. All low-side IGBTs are shut down when the temperature exceeds this threshold. Refer to Figure 2-3 and Chapter 3.8 for details.
T_{OH} Hysteresis	$T_{OH(hys)}$	Hysteresis temperature that does not reset the protection status during overheating protection. Refer to Figure 2-3 and Chapter 3.8 for details. T_{OH} and $T_{OH(hys)}$ are applied to overheating protection model.
V_{CC} Under Voltage Trip Level of Low-side	$V_{CCL(OFF)}$	Tripping voltage of under voltage protection of low-side control power supply. When V_{CCL} falls below the threshold voltage, all low-side IGBTs are shut down. Refer to Chapter 3.1 for details.
V_{CC} Under Voltage Reset Level of Low-side	$V_{CCL(ON)}$	Reset voltage that resets the under voltage protection of low-side control power supply. Refer to Chapter 3.1 for details.
V_{CC} Under Voltage Hysteresis of Low-side	$V_{CCL(hys)}$	Hysteresis voltage between $V_{CCL(OFF)}$ and $V_{CCL(ON)}$,

*1 If the pulse width of the input signal is less than $t_{IN(on)}$ or $t_{IN(off)}$, the product might make incorrect response.

Table 2-3 Description of terminology (Control Circuit Block) (Continued)

Item	Symbol	Description
V_{CC} Under Voltage Trip Level of High-side	$V_{CCH(OFF)}$	Tripping voltage of under voltage protection of high-side control power supply. When $V_{CCH(U)}$, $V_{CCH(V)}$ or $V_{CCH(W)}$ falls below the threshold voltage, the corresponding high-side IGBTs are shut down. Refer to Chapter 3.1 for details.
V_{CC} Under Voltage Reset Level of High-side	$V_{CCH(ON)}$	Reset voltage that resets the under voltage protection of high-side control power supply. Refer to Chapter 3.1 for details.
V_{CC} Under Voltage Hysteresis of High-side	$V_{CCH(hys)}$	Hysteresis voltage between $V_{CCH(OFF)}$ and $V_{CCH(ON)}$.
V_B Under Voltage Trip Level	$V_{B(OFF)}$	Tripping voltage of under voltage protection of high-side bias voltage. When $V_{B(U)}$, $V_{B(V)}$, $V_{B(W)}$ falls below the threshold voltage, the corresponding high-side IGBT is shut down. Refer to Chapter 3.2 for details.
V_B Under Voltage Reset Level	$V_{B(ON)}$	Reset voltage that resets the under voltage protection of high-side bias voltage. Refer to Chapter 3.2 for details.
V_B Under Voltage Hysteresis	$V_{B(hys)}$	Hysteresis voltage between $V_{B(OFF)}$ and $V_{B(ON)}$.
Forward Voltage of Bootstrap Diode	$V_{F(BSD)}$	Forward voltage when a specified forward current flows through BSD.
Built-in Limiting Resistance	$R_{(BSD)}$	Built-in current limiting resistor resistance value of bootstrap circuit.

Table 2-4 Description of terminology (Thermal Characteristics)

Item	Symbol	Description
Junction to Case Thermal Resistance (per single IGBT)	$R_{th(j-c)\_IGBT}$	Thermal resistance from junction to case of a single IGBT.
Junction to Case Thermal Resistance (per single Diode)	$R_{th(j-c)\_FWD}$	Thermal resistance from junction to case of a single FWD.

Table 2-5 Description of terminology (Mechanical Characteristics)

Item	Symbol	Description
Mounting Torque of Screws	M_S	Maximum screwing torque when mounting the IPM to a cooling body with specified screws.
Heat-sink Side Flatness	-	Flatness of the IMS's aluminum surface. Refer to Fig. 2-4.
Weight	-	Weight of a single IPM.
Resistance to Soldering Heat	-	Number of times of solder heat resistance under specified conditions.

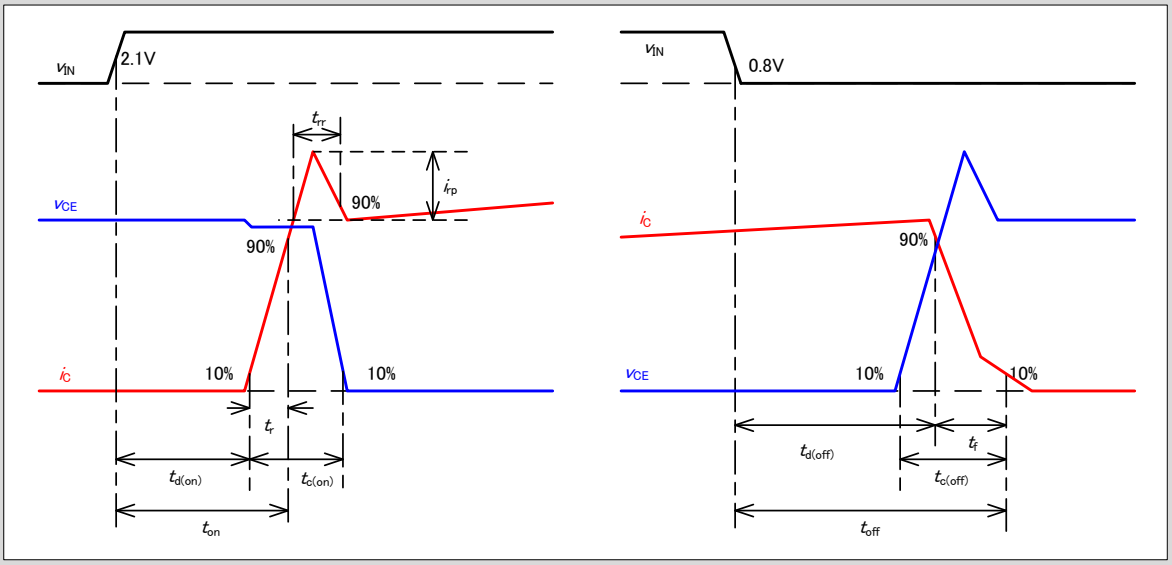


Fig. 2-2 Definition of switching time

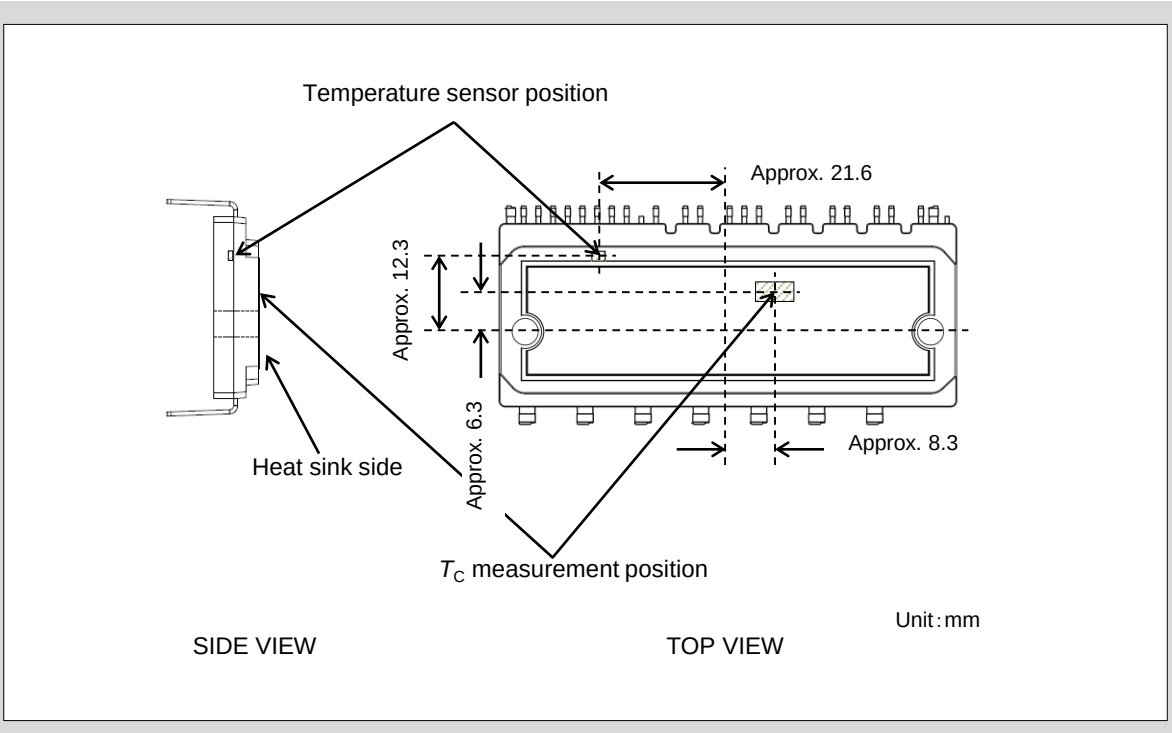


Fig. 2-3 Temperature sensor position and T_c measurement position

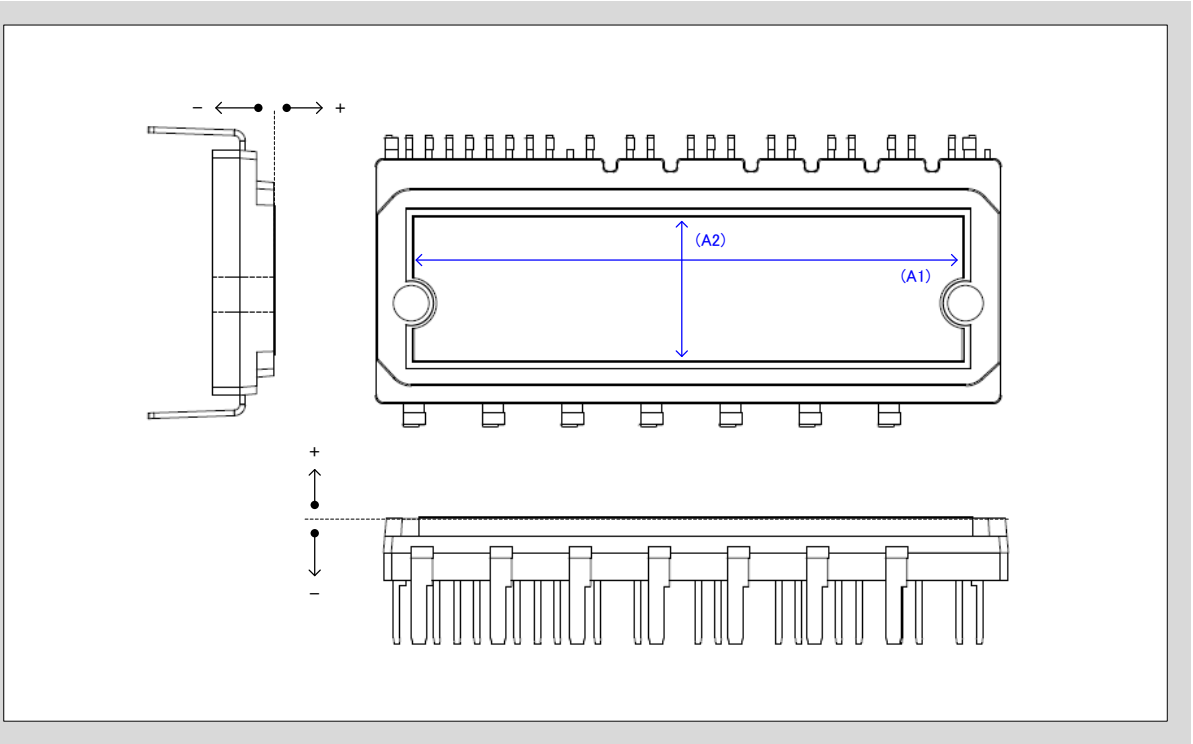


Fig. 2-4 Measurement point of heat sink surface flatness