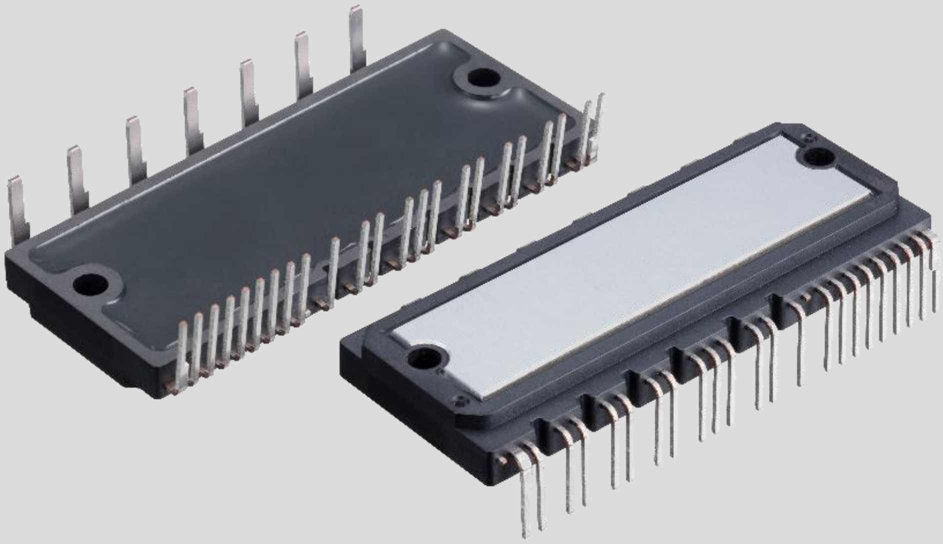


Small IPM (Intelligent Power Module)

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 1 Product Outline

This manual describes the following contents for Fuji IGBT Intelligent Power Module "Small IPM P642 series"

- Product summary
- Explanation of terminal symbols and terms
- Detailed explanation and design guideline of control terminals and power terminals
- Recommended wiring, layout and mounting guidelines

1. Introduction

<Product overview>

- IGBT modules used in inverters for compressors and air conditioner fans are developing rapidly in response to the growing demand for energy saving, equipment miniaturization and weight reduction.
- IGBTs are devices that combine the high-speed switching performance of power MOSFETs and the high-voltage, high-current capabilities of bipolar transistors, and are expected to further develop in the future.
- Among them, the IPM (Intelligent Power Module) is a 3-phase IGBT inverter bridge circuit with integrated gate drive circuits and protection circuits.

<Product features>

- 7th generation IGBT technology reduces power loss and realizes energy saving of equipment.
- Expansion of operating current by guaranteed T_{vjop}=150^{o}C and time limited T_{vj}=175^{o}C operation.
- Expansion of overload operating area by higher accuracy of short circuit protection detection.
- Lineup of 650V / 50A, 75A.
- Total power loss is reduced by improving the trade-off between Collector-Emitter saturation voltage $V_{CE(sat)}$ and switching loss.

<Internal circuit>

- The control IC of upper side arms have built-in high voltage level shift circuit (HVIC).
- Both the low-side and high-side IGBTs can be driven directly by a microprocessor. The voltage level of input signal is 3.3V or 5.0V.
- No reverse bias power supply is required due to the wiring length between the built-in drive circuit and IGBT is short and the impedance of the drive circuit is low.
- IPM has built-in bootstrap diodes (BSD) and can be driven by a single power supply. No insulated power supplies for the high-side drive are needed.

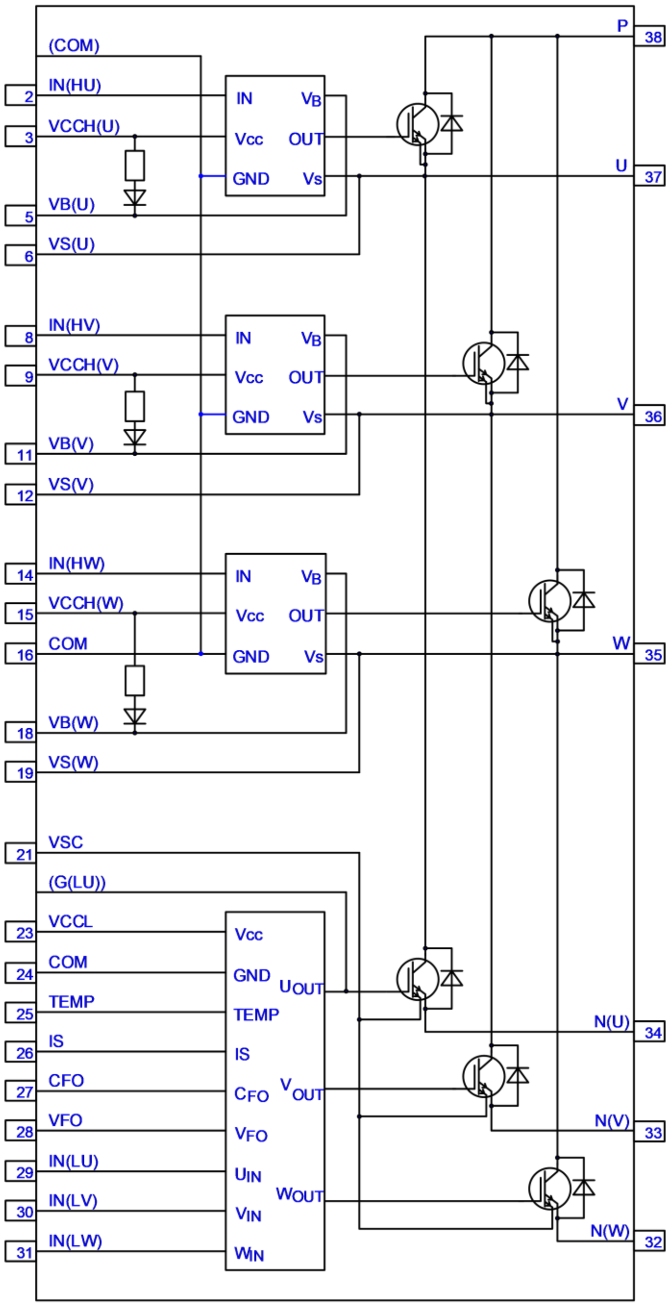


Fig.1-1 Internal circuit diagram

<Built-in protection circuit>

- The following built-in protection circuits are incorporated in the product:
  - (OC): Overcurrent protection
  - (UV): Under voltage protection for power supplies of control IC
  - (LT): Temperature sensor output function
  - (OH): Overheating protection (only applied to some products)
  - (FO): Fault status output
- The OC protection circuit protects the IGBT from overcurrent due to load short-circuit and arm short-circuit. This protection circuit adopts both sense current method and external shunt resistor method, thus arm short-circuit protection is possible.
- The UV protection circuit is triggered when there is voltage drop at the control power supply and the high-side drive power supply. It is integrated into all IGBT drive circuits.
- The OH protection circuit protects the product from overheating. It is built into the low-side control IC (LVIC).
- The temperature sensor output function outputs temperature as analog voltage. It is built into LVIC.
- The FO function outputs a fault signal when the product detects abnormal conditions. By outputting a fault signal to the microprocessor unit (MPU), it is possible to shut down and prevent destruction of the system.

<Compact package>

- This product uses aluminum insulated metal substrate (IMS) and has excellent heat dissipation.
- The pitch between control terminals is 2.54mm.
- The pitch between power terminals is 10mm.

Fig.1-2 Package external view

2. Product Lineup and Target Application

Table 1-1 Lineup

Type Name	IGBT Rating		Isolation Voltage [Vrms]	Variation *1
	Voltage [V]	Current [A]		
6MBP50XTA065-50	650	50	2500Vrms Sinusoidal 60Hz, 1min. (Between all shorted terminals and IMS)	LT
6MBP50XTC065-50				LT OH
6MBP75XTA065-50		75		LT
6MBP75XTC065-50				LT OH

*1 (LT): Temperature sensor output function
(OH): Overheating protection function

3. Definition of Type Name

• Type Name

6 MBP 50 X T C 065 –50

- –50: Additional model number (Option)
  50 : RoHS
- 065: Voltage rating
  065 : 650V
- C: Additional series code
  A : Temperature sensor output
  C : Temperature sensor output and Overheat protection
- T: Series name
  T: Package type
- X: Series name
  X: Chip generation
- 50: IGBT current rating
  50:50A, 75:75A
- MBP: Indicates IGBT-IPM
- 6: Number of switching elements
  6 : 6 switching elements

Fig. 1-3 Definition of Type

4. Marking Specification

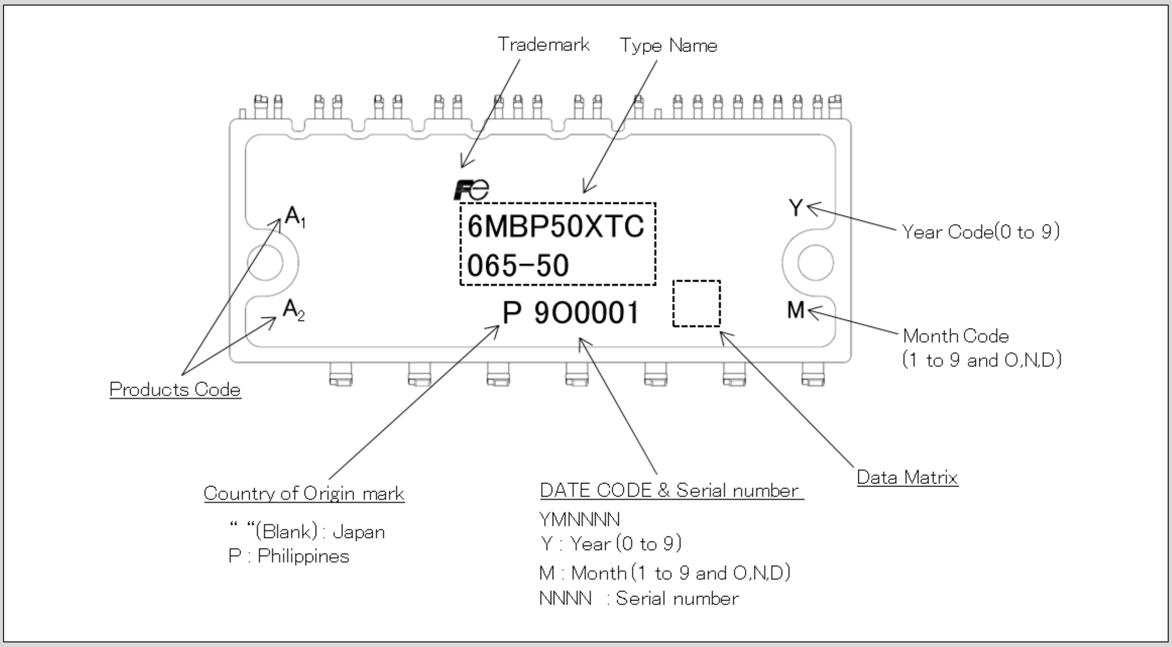
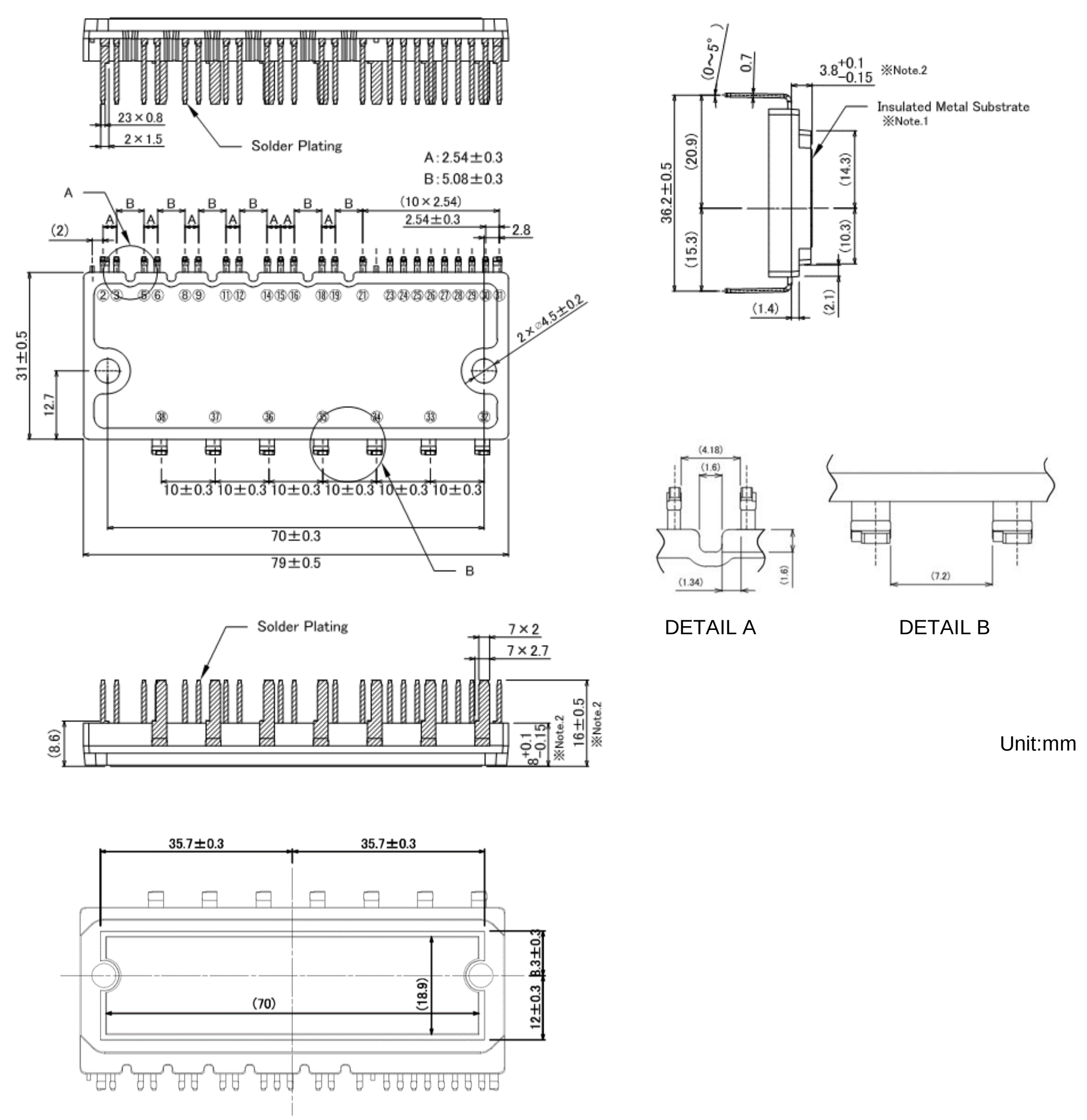


Fig. 1-4 Marking specification

Table 1-2 Products code

TYPE NAME	PRODUCT CODE	
	A_1	A_2
6MBP50XTA065-50	A	A
6MBP50XTC065-50	A	C
6MBP75XTA065-50	B	A
6MBP75XTC065-50	B	C

5. Package Outline Dimension



Note.1
The IMS (Insulated Metal Substrate) is deliberately protruded to improve the thermal conductivity between IMS and heat-sink.

Note.2
Thickness from the package surface to the back side including the IMS.

Fig. 1-5 Case outline drawing

6. Absolute Maximum Ratings

An example of the absolute maximum ratings of 6MBP50XTA065-50 is shown in Table 1-3 and Table 1-4.

Table 1-3 Inverter Block Absolute Maximum Ratings at T_{vj}=25ºC, T_c=25ºC, V_{CC}[*1]=15V, $V_{B(*)}$=15V (unless otherwise specified)

Item	Symbol	Rating	Unit	Description
DC Bus Voltage	$V_{DC\ (terminal)}$	450	V	DC voltage that can be applied between P-N(U), N(V), N(W) terminals. Please refer to Fig. 1-5 for details.
Bus Voltage (Surge)	$V_{DC(Surge,\ terminal)}$	500	V	Peak value of the surge voltage that can be applied between P-N(U),N(V),N(W) terminals during switching operation. Please refer to Fig. 1-5 for details.
Collector-Emitter Voltage	$V_{CE(chip)}$	650	V	Maximum collector-emitter voltage of IGBT and repeated peak reverse voltage of FWD. Please refer to Fig. 1-5 for details.
Collector Current	I_C	50	A	Maximum collector current of IGBT at T_c=25ºC, T_{vj}=150ºC[*2]
Peak Collector Current	I_{CP}	100	A	Maximum pulse collector current of IGBT at T_c=25ºC, T_{vj}=150ºC[*2]
Forward Current	I_F	50	A	Maximum forward current of FWD at T_c=25ºC, T_{vj}=150ºC[*2]
Peak Forward Current	I_{FP}	100	A	Maximum pulse forward current of FWD at T_c=25ºC, T_{vj}=150ºC[*2]
Collector Power Dissipation	P_{D_IGBT}	132	W	Maximum power dissipation per IGBT at T_c=25ºC, T_{vj}=150ºC[*2]
FWD Power Dissipation	P_{D_FWD}	89	W	Maximum power dissipation per FWD at T_c=25ºC, T_{vj}=150ºC[*2]
Self Protection DC Bus Voltage (arm short-circuit)	$V_{DC(sc)}$	400	V	Maximum DC voltage at which IGBT can be safely shut off by the IPM's protection function during short-circuit or overcurrent. Please refer to Fig. 1-5 for details.
Maximum Virtual Junction Temperature of Inverter Block	T_{vj}	175	ºC	Maximum virtual junction temperature of IGBT and FWD[*3]
Operating Virtual Junction Temperature of Inverter Block	T_{vjop}	-40 ~ +150	ºC	Virtual Junction Temperature of IGBT and FWD during continuous operation [*3]

[*1] V_{CC} is applied between VCCH(U,V,W)-COM and VCCL-COM terminals.

[*2] Pulse width and duty are limited by T_{vj}.

[*3] The maximum virtual junction temperature during continuous operation is T_{vj}=150ºC. Continuous operation at over T_{vj}=150ºC may result in degradation of product lifetime such as power cycling capability with respect to the designed lifetime.

Table 1-4 Control Circuit Block Absolute Maximum Ratings at T_{vj}=25ºC, T_c=25ºC,V_{CC} [*1]=15V, $V_{B(*)}$=15V (continued)

Item	Symbol	Rating	Unit	Description
High-side Supply Voltage	$V_{CCH(U)}$ $V_{CCH(V)}$ $V_{CCH(W)}$	-0.5 ~ 20	V	Voltage that can be applied between VCCH(U) - COM, VCCH(V) - COM, VCCH(W) - COM terminals.
Low-side Supply Voltage	V_{CCL}	-0.5 ~ 20	V	Voltage that can be applied between VCCL-COM terminals.
High-side Bias Absolute Voltage	$V_{VB(U)-COM}$ $V_{VB(V)-COM}$ $V_{VB(W)-COM}$	-0.5 ~ 670	V	Voltage that can be applied between VB(U)-COM, VB(V)-COM, VB(W)-COM terminals.
High-side Bias Voltage for IGBT Gate Driving	$V_{B(U)}$ $V_{B(V)}$ $V_{B(W)}$	-0.5 ~ 20	V	Voltage that can be applied between VB(U)-VS(U), VB(V)-VS(V), VB(W)-VS(W) terminals.
High-side Bias Offset Voltage	V_U V_V V_W	-5 ~ 650	V	Voltage that can be applied between U-COM, V-COM, W-COM terminals.[*4]
Input Signal Voltage	V_{IN}	-0.5 ~ V_{CCH}+0.5 -0.5 ~ V_{CCL}+0.5	V	Voltage that can be applied between IN(HU)-COM, IN(HV)-COM, IN(HW)-COM, IN(LU)-COM, IN(LV)-COM, IN(LW)-COM terminals.
Input Signal Current	I_{IN}	3	mA	Maximum current between IN(HU)-COM, IN(HV)-COM, IN(HW)-COM, IN(LU)-COM, IN(LV)-COM, IN(LW)-COM terminals.
Fault Signal Voltage	V_{FO}	-0.5 ~ V_{CCL}+0.5	V	Voltage that can be applied between VFO-COM terminals.
Fault Signal Current	I_{FO}	1	mA	Maximum sink current between VFO-COM terminals.

(Continued on next page.)

[*4] Apply 13.0V or more between VB(U)-U, VB(V)-V, VB(W)-W terminals.
The product might malfunction if the high-side bias offset voltage is less than -5V.

Table 1-4 Control Circuit Block Absolute Maximum Ratings at T_{vj}=25°C, T_c=25°C, V_{CC} [*1]=15V, $V_{B(*)}$=15V (continued)

Item	Symbol	Rating	Unit	Description
CFO Signal Voltage	V_{CFO}	-0.5 ~ 5.0	V	Voltage that can be applied between CFO-COM terminals.[*5]
CFO Signal Current	I_{CFO}	-0.05 / 3	mA	Maximum source / sink current between CFO-COM terminals.[*5]
Over Current Sensing Input Voltage	V_{IS}	-0.5 ~ V_{CCL}+0.5	V	Voltage that can be applied between IS-COM terminals.
TEMP Signal Voltage	V_{TEMP}	-0.5 ~ 5.0	V	Voltage that can be applied between TEMP-COM terminals.
TEMP Signal Current	I_{TEMP}	-0.05 / 3	mA	Maximum source / sink current between TEMP-COM terminals.
VSC Signal Voltage	V_{VSC}	-0.5 ~ V_{CCL}+0.5	V	Voltage that can be applied between VSC-COM terminals.[*6]
VSC Signal Current	I_{VSC}	-20	mA	Maximum source current between VSC-COM terminals.[*6]
Virtual Junction Temperature of Control Circuit Block	T_{vj}	150	°C	Maximum virtual junction temperature of the control circuit.
Operating Case Temperature	T_c	-40 ~ +125	°C	Operating case temperature (temperature of IMS directly under the IGBT or FWD chip).
Storage Temperature	T_{stg}	-40 ~ +125	°C	Ambient temperature range for storage and transportation (no load condition).
Isolation Voltage	V_{isol}	AC 2500	Vrms	Maximum voltage between IMS and all shorted terminals (Sine wave 60Hz, 1min)

[*5] CFO is output terminal. Do not apply voltage or current. Connect only the specified capacitor between CFO-COM terminals.

[*6] VSC is output terminal. Do not apply voltage or current. Connect only the specified resistor between VSC-COM terminals.

<Absolute Maximum Rating of Collector-Emitter Voltage>

The absolute maximum rating of collector-emitter voltage of the IGBT is specified below. During operation, the voltage between P-N(U, V, W) is usually applied to high-side or low-side of one phase. Therefore, the voltage between P-N(U, V, W) must not exceed the absolute maximum rating of IGBT. The collector-emitter voltage absolute maximum rating is described below.

$V_{CE(chip)}$: Breakdown voltage of IGBT and FWD chip. Because it is difficult to measure directly, please use the product with $V_{DC(terminal)}$, $V_{DC(Surge,terminal)}$ within the absolute maximum rating.

$V_{DC(terminal)}$: DC bus voltage (between P-N(U, V, W) terminals)

$V_{DC(Surge, terminal)}$: DC bus voltage at P-N(U, V, W) terminals including surge voltage generated during switching.

- Fig.1-5 shows the waveforms during short-circuit, IGBT turn-off and FWD reverse recovery. Since $V_{DC(Surge, terminal)}$ is different in each situation, it is necessary to set $V_{DC(terminal)}$ considering these situations.
- $V_{CE(chip)}$ is the collector-emitter voltage absolute maximum rating of the IGBT chip. $V_{DC(Surge, terminal)}$ is specified considering the margin of surge voltage generated by the wiring inductance inside the Product.
- $V_{DC(terminal)}$ is specified considering the margin of surge voltage generated by the wiring inductance between P-N(*) terminals and electrolytic capacitor.

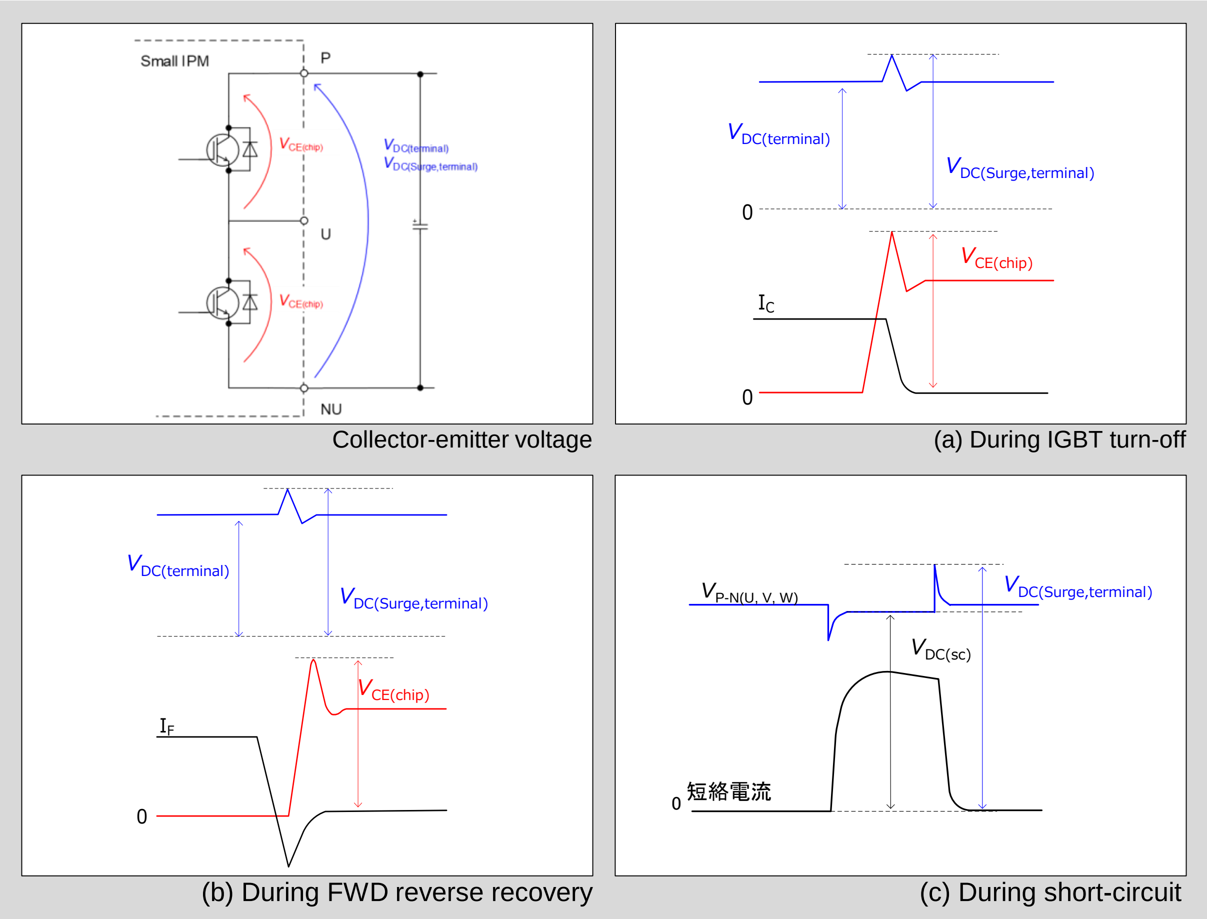


Fig.1-6 Waveforms and Collector-Emitter voltage during IGBT turn-off, FWD reverse recovery, and short-circuit