IPM G1-series

APPLICATION NOTE

Index

1. Product Line-up

A package

VCES [V]	Circuit	I_C [A]	Main terminal			
			Straight layout		L-shaped layout	
			Pin type	Screw type	Pin type	Screw type
600V	6in1	50A	PM50CG1AP065	PM50CG1A065	PM50CG1APL065	PM50CG1AL065
		75A	PM75CG1AP065	PM75CG1A065	PM75CG1APL065	PM75CG1AL065
		100A	PM100CG1AP065	PM100CG1A065	PM100CG1APL065	PM100CG1AL065
	7in1	50A	PM50RG1AP065	PM50RG1A065	-	-
		75A	PM75RG1AP065	PM75RG1A065	-	-
1200V	6in1	25A	PM25CG1AP120	PM25CG1A120	PM25CG1APL120	PM25CG1AL120
		35A	PM35CG1AP120	PM35CG1A120	PM35CG1APL120	PM35CG1AL120
		50A	PM50CG1AP120	PM50CG1A120	PM50CG1APL120	PM50CG1AL120
	7in1	25A	PM25RG1AP120	PM25RG1A120	-	-
		35A	PM35RG1AP120	PM35RG1A120	-	-

B package, C package

VCES [V]	Circuit	I_C [A]	Main terminal	
			Screw type	
			B-package	C-package
600V	6in1	50A	PM50CG1B065	-
		75A	PM75CG1B065	-
		100A	PM100CG1B065	-
		150A	PM150CG1B065	-
		200A	PM200CG1B065	PM200CG1C065
		300A	-	PM300CG1C065
		450A	-	PM450CG1C065
	7in1	50A	PM50RG1B065	-
		75A	PM75RG1B065	-
		100A	PM100RG1B065	-
		150A	PM150RG1B065	-
		200A	PM200RG1B065	PM200RG1C065
		300A	-	PM300RG1C065
		450A	-	PM450RG1C065
1200V	6in1	25A	PM25CG1B120	-
		35A	PM35CG1B120	
		50A	PM50CG1B120	-
		75A	PM75CG1B120	-
		100A	PM100CG1B120	PM100CG1C120
		150A	-	PM150CG1C120
		200A	-	PM200CG1C120
	7in1	25A	PM25RG1B120	-
		35A	PM35RG1B120	-
		50A	PM50RG1B120	-
		75A	PM75RG1B120	-
		100A	PM100RG1B120	PM100RG1C120
		150A	-	PM150RG1C120
		200A	-	PM200RG1C120

A package Main terminal layout

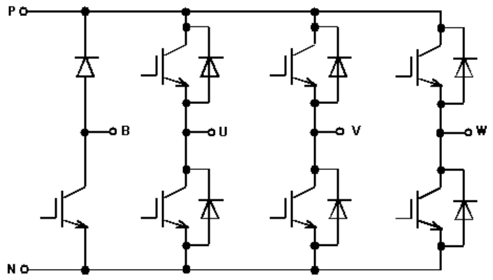
CG1A / CG1AP
：Main terminal(Straight layout)

CG1AL / CG1APL
：Main terminal(L-shaped layout)

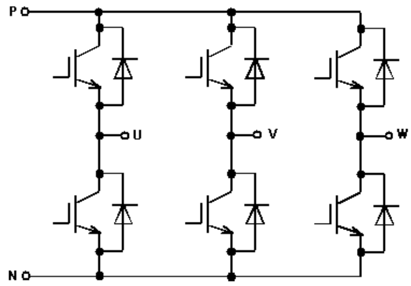
Straight terminal layout

L-shaped terminal layout

2.Internal circuit

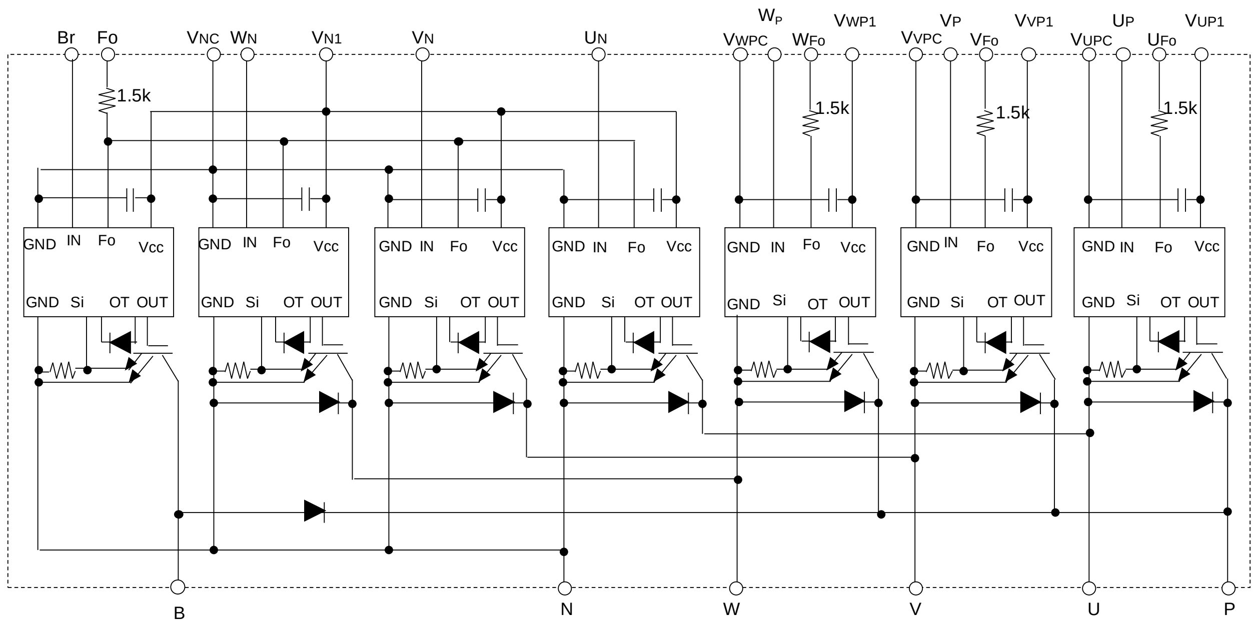


7in1 (Inverter+ Brake)



6in1 (Inverter)

Ex.) 7in1 (Inverter+ Brake)



3.Applications of IPM to General purpose Inverter (reference)

■AC220V

Motor Ratings (kW)	For Inverter Module
	G1 series
3.7	PM50RG1AP065、PM50RG1A065、PM50RG1B065 PM50CG1AP065、PM50CG1A065、PM50CG1APL065、PM50CG1AL065、PM50CG1B065
5.5/7.5	PM75RG1AP065、PM75RG1A065、PM75RG1B065 PM75CG1AP065、PM75CG1A065、PM75CG1APL065、PM75CG1AL065、PM75CG1B065
11.0	PM100CG1AP065、PM100CG1A065、PM100CG1APL065、PM100CG1AL065、 PM100CG1B065、PM100RG1B065
15.0/18.5	PM150RG1B065 、PM150CG1B065
22.0	PM200RG1B065、PM200RG1C065、PM200CG1B065、PM200CG1C065
30.0	PM300RG1C065、PM450RG1C065、PM300CG1C065、PM450CG1C065

■AC440V

Motor Ratings (kW)	For Inverter Module
	G1 series
5.5	PM25RG1AP120、PM25RG1A120、PM25RG1B120 PM25CG1AP120、PM25CG1A120、PM25CG1APL120、PM25CG1AL120、PM25CG1B120
7.5	PM50RG1AP120、PM50RG1A120、PM50RG1B120 PM50CG1AP120、PM50CG1A120、PM50CG1APL120、PM50CG1AL120、PM50CG1B120
11.0/15.0	PM75RG1B120、PM75CG1B120
18.5/22.0	PM100RG1C120、PM100CG1B120、PM100CG1C120
30.0	PM150RG1C120、PM200RG1C120、PM150CG1C120、PM200CG1C120

*It is possible to apply 35A/1200V (ex.PM35CG1A120) to motor rating 5.5 ~ 7.5kW depended on operating condition.

Applications of IPM to Servo Motor Controls (reference)

■AC220V

Motor Ratings (kW)	For Inverter Module
	G1 series
~1.5	PM50CG1AP065、PM50CG1A065、PM50CG1APL065、PM50CG1AL065、PM50CG1B065
~2.0	PM75CG1AP065、PM75CG1A065、PM75CG1APL065、PM75CG1AL065、PM75CG1B065
~3.5	PM100CG1AP065、PM100CG1A065、PM100CG1APL065、PM100CG1AL065、 PM100CG1B065
~6.0	PM150CG1B065
~7.5	PM200CG1B065、PM200CG1C065
~15	PM300CG1B065、PM300CG1C065、PM450CG1C065

■AC440V

Motor Ratings (kW)	For Inverter Module
	G1 series
~1.5	PM25CG1AP120、PM25CG1A120、PM25CG1APL120、PM25CG1AL120、PM25CG1B120
~3.0	PM50CG1AP120、PM50CG1A120、PM50CG1APL120、PM50CG1AL120、PM50CG1B120
~5.0	PM75CG1B120
~6.0	PM100CG1B120、PM100CG1C120
~7.5	PM150CG1B120、PM150CG1C120, PM200CG1C120

*It is possible to apply 35A/1200V (ex.PM35CG1A120) to motor rating 1.5~3.0kW depended on operating condition.

These module selections are reference, and it is not restricted module selection by these reference
It is necessary to select and consider the power-module (IPM) from system operating condition.

4. Term Explanation

General 1

Symbol	Parameter	Definition
IGBT	Insulated Gate Bipolar Transistor	
FWDi	Free Wheeling Diode	anti-parallel to the IGBT
IPM	Intelligent Power Module	
tdead	Dead Time	Low side turn-off to high Side turn-on & High Side turn-off to low side turn-on
IPM Motor	Interior Permanent Magnet Motor	
CMR	Common Mode Noise Reduction	The maximum rise ratio of common mode voltage
CM_H		The maximum rise ratio of common mode voltage at the specific high level
CM_L		The maximum rise ratio of common mode voltage at the specific low level
CTR	Current Transfer Ratio	the ratio of the output current to the input current

General 2

Symbol	Parameter	Definition
T_a	Ambient Temperature	Atmosphere temperature without being subject to thermal source
T_c	Case Temperature	Case temperature measured at specified point

Absolute maximum Ratings

Symbol	Parameter	Definition
V_{CES}	Collector-Emitter Blocking Voltage	Maximum Off-state collector-emitter voltage at applied control input off signal
I_C	Continuous Collector Current	Maximum collector current – DC
I_{CRM}	Peak Collector Current Repetitive	Peak collector current, Tvj≤150°C
P_{tot}	Power Dissipation	Maximum power dissipation, per device, T_C=25°C
Tvj	Junction Temperature	Allowable range of IGBTvjunction temperature during operation
T_{stg}	Storage Temperature	Allowable range of temperature within which the module may be stored or transported without being subject to electrical load.
V_{isol}	Isolation Voltage	Minimum RMS isolation voltage capability applied electric terminal to base plate, 1 minute duration
-	Mounting Torque	Allowable tightening torque for terminal and mounting screws

Electrical Characteristics

Symbol	Parameter	Definition
I_{CES}	Collector-Emitter Leakage Current	I_C at V_{CE} = V_{CES}, V_{CIN} = 15V
V_{CEsat}	Collector-Emitter Saturation Voltage	V_{CE} at I_C = rated I_C and V_D = 15V
tc(on)	Turn-on Crossover Time	Time from I_C=10% to V_{CE}=10% of final value
tc(off)	Turn-off Switching loss	Time from V_{CE}=10% to I_C=10% of final value
E_{on}	Turn-on Switching Energy	Energy dissipated inside the IGBT during the turn-on of a single collector current pulse. Integral time starts from the 10% rise point of the collector current and ends at the 10% of the collector-emitter voltage point.
E_{off}	Turn-off Switching Energy	Energy dissipated inside the IGBT during the turn-off of a single collector current pulse. Integral time starts from the 10% rise point of the collector-emitter voltage and ends at the 10% of the collector current point.
t_{rr}	Diode Reverse Recovery Time	Time from I_C=0A to projection of zero I_C from Irr and 0.5×Irr points with I_E = rated I_C.
V_{EC}	Forward Voltage Drop of Diode	V_{EC} at -I_C = rated Ic
R_{th}	Thermal Resistance	The rise of junction temperature per unit of power applied for a given time period
$R_{th(j-c)}$	Thermal Resistance, Junction to Case	I_C conducting to establish thermal equilibrium
$R_{th(c-s)}$	Thermal Resistance, Case to heat sink	I_C conducting to establish thermal equilibrium lubricated

5. Numbering System

Label)

Common label for all packages
(Representative example : PM50RG1B060)

PM50RG1B065
MADE IN JAPAN (Lot No) G
MITSUBISHI ELECTRIC

Type Name)

PM 50 R G1B 065 – 300G

- 300G — Suffix Number (Not printed on the label)
- 065 — Voltage Class
  - 065: 650V ,120: 1200V
- G1B — Package
  - G1: G1 series
    - G1A:A package, Main terminal Screw type (Straight layout)
    - G1AL:A package, Main terminal Screw type (L-shaped layout)
    - G1AP:A package, Main terminal Pin type (Straight layout)
    - G1APL:A package, Main terminal Pin type (L-shaped layout)
    - G1B:B package, Main terminal Screw type
    - G1C:C package, Main terminal Screw type
- R — Circuit
  - R:7in1 (Inverter+ Brake) C:6in1 (Inverter)
- 50 — Collector Current rating
  - 50: Ic=50A ,75: Ic=75A
- PM — PM: Intelligent power Module(IPM)

Lot Number)

S 4 1 AH1

- AH1 — Manufacturing lot management number
- 1 — Manufacturing month (Jan~ Sept.: 1 ~ 9, Oct.: O, Nov.: N, Dec.: D)
- 4 — Manufacturing year (the last digit of year, 5=2015 0=2020 ..)
- S — UL ID code (UL certified products only)

2D code specifications)

Item	Specification
Symbology	Data Matrix (ECC200)
Data type	alphanumeric (ASCII) characters
Error correction ability	20 ~ 35 %
Symbol size	6.0 mm × 6.0 mm
Code size	24 cell × 24 cell
Cell size	0.25 mm
Data size	52 letters

Data contents

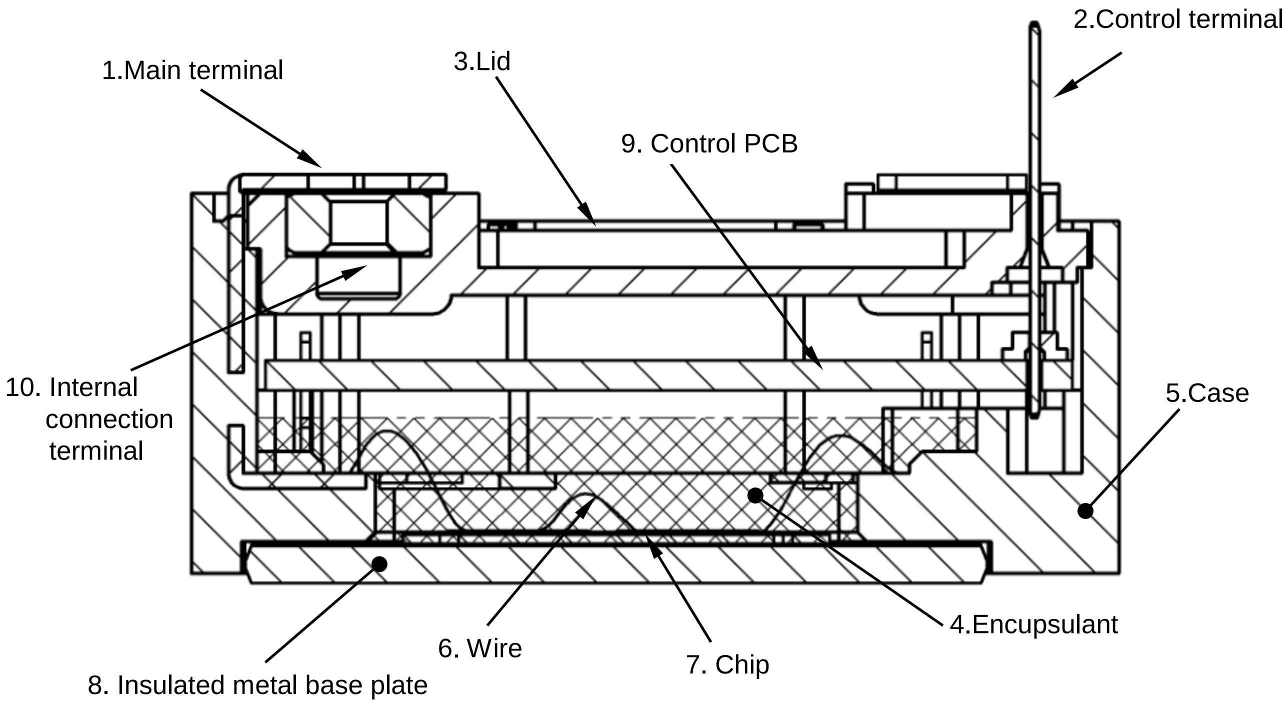
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
P	M	5	0	R	G	1	B	0	6	5	SP	SP	SP	SP	SP	SP	SP	3	0	0	G	SP	SP	SP	SP
Type name																		Suffix							

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
SP	S	4	1	A	H	1	G	SP	5	0	A	SP	SP	6	5	0	V	SP	SP	SP	SP	SP	SP	SP	SP
	Lot Number								Current					Voltage											

Data contents example: "SP" means space, equivalent to ASCII code number 32.

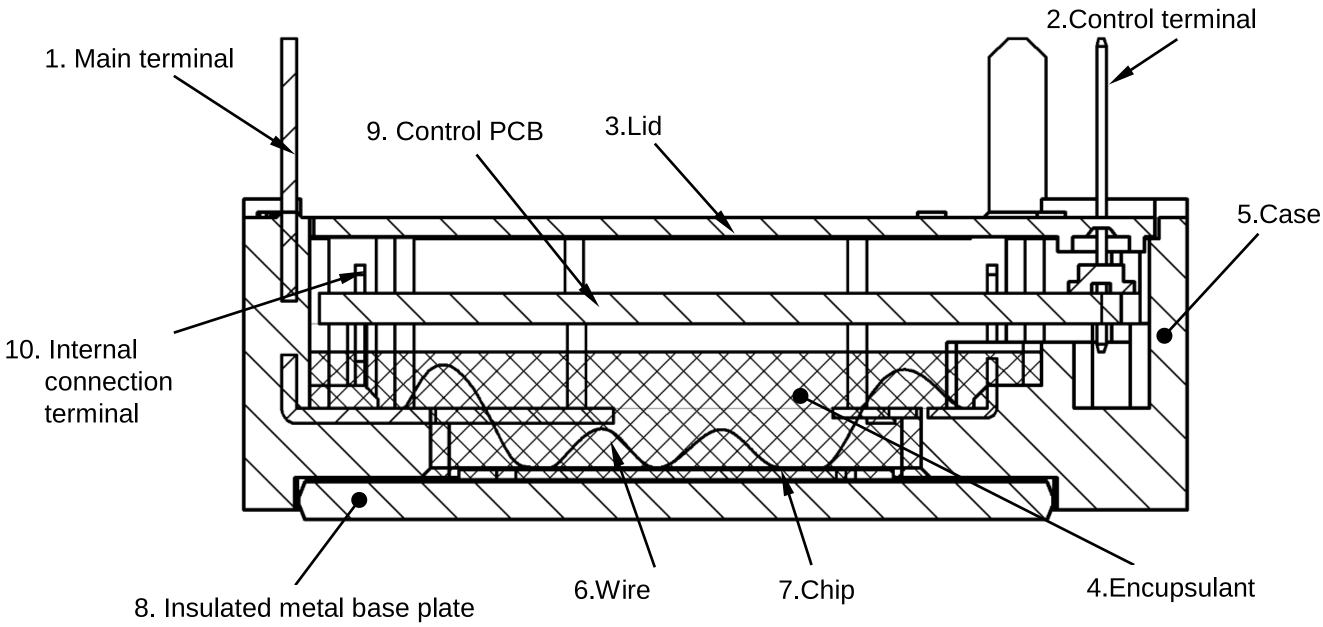
6. Structure

ex.) A package Screw type



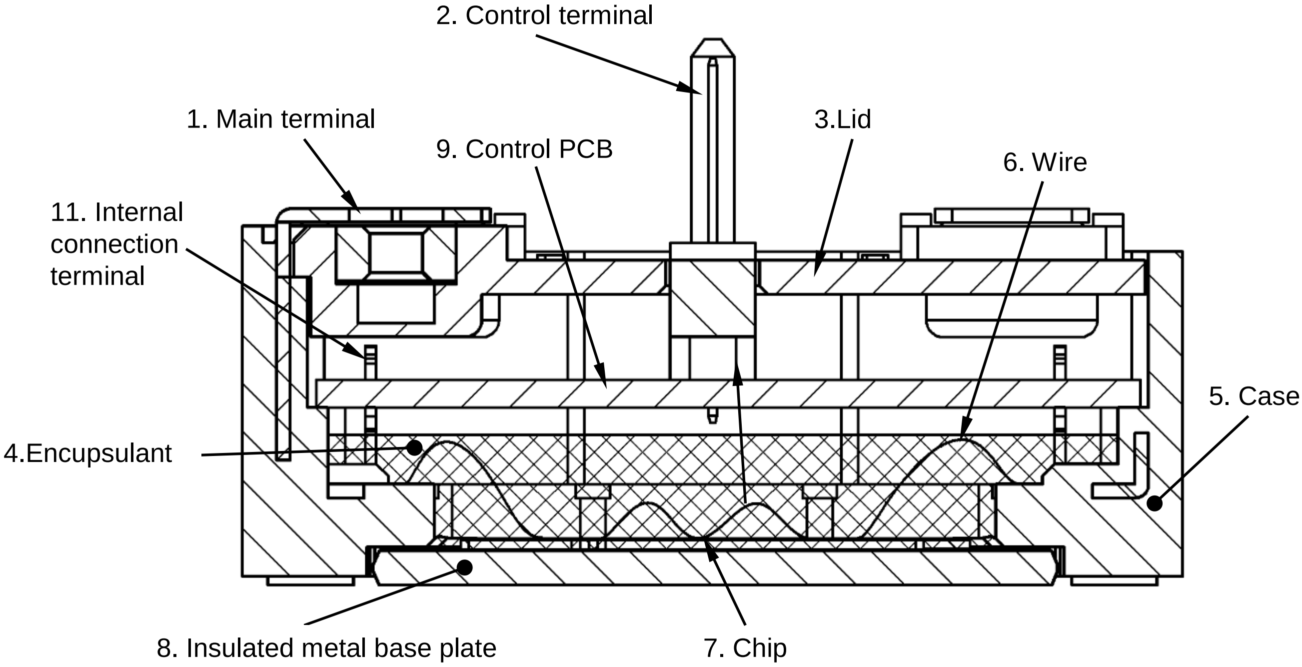
	Part	Material	UL Flame class
1	Main terminal	Copper plated with nickel	
2	Control terminal	Terminal : Brass plated with Ni+Au	
		Housing : PPS resin	UL 94V-0
3	Lid	PPS resin	UL 94V-0
4	Encupsulant	Epoxy resin	UL 94V-0
5	Case	PPS	UL 94V-0
6	Wire	Aluminum (Al)	
7	Chip	Silicon (Si)	
8	Insulated metal base plate	Insulation sheet : resin	UL 94V-0
		Base plate : Copper plated with Ni	
9	Control PCB	Glass epoxy	UL 94V-0
10	Internal connection terminal	Copper plated with nickel	

ex.) A package Pin type



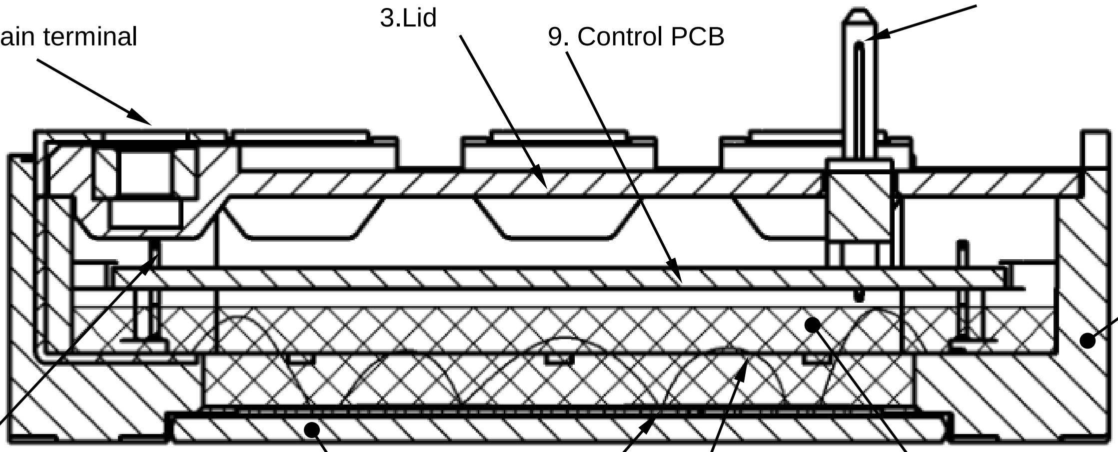
	Part	Material	UL Flame class
1	Main terminal	Copper plated with nickel	
2	Control terminal	Terminal : Brass plated with Ni+Sn	
		Housing : PPS resin	UL 94V-0
3	Lid	PPS resin	UL 94V-0
4	Encupsulant	Epoxy resin	UL 94V-0
5	Case	PPS	UL 94V-0
6	Wire	Aluminum (Al)	
7	Chip	Silicon (Si)	
8	Insulated metal base plate	Insulation sheet : resin	UL 94V-0
		Base plate : Copper plated with Ni	
9	Control PCB	Glass epoxy	UL 94V-0
10	Internal connection terminal	Copper plated with nickel	

ex.) B package



	Part	Material	UL Flame class
1	Main terminal	Copper plated with nickel	
2	Control terminal	Terminal : Brass plated with Ni+Au	
		Housing : PBT resin	UL 94V-0
3	Lid	PPS resin	UL 94V-0
4	Encupsulant	Epoxy resin	UL 94V-0
5	Case	PPS	UL 94V-0
6	Wire	Aluminum (Al)	
7	Chip	Silicon (Si)	
8	Insulated metal base plate	Insulation sheet : resin	UL 94V-0
		Base plate : Copper plated with Ni	
9	Control PCB	Glass epoxy	UL 94V-0
10	Internal connection terminal	Copper plated with nickel	

ex.) C package



	Part	Material	UL Flame class
1	Main terminal	Copper plated with nickel	
2	Control terminal	Terminal : Brass plated with Ni+Au	
		Housing : PBT resin	UL 94V-0
3	Lid	PPS resin	UL 94V-0
4	Encupsulant	Epoxy resin	UL 94V-0
5	Case	PPS	UL 94V-0
6	Wire	Aluminum (Al)	
7	Chip	Silicon (Si)	
8	Insulated metal base plate	Insulation sheet : resin	UL 94V-0
		Base plate : Copper plated with Ni	
9	Control PCB	Glass epoxy	UL 94V-0
10	Internal connection terminal	Copper plated with nickel	

*These structure shows reference as an example structure. It does not show exact dimension and layout.
And, These structure does not show all components in each package.

7. Safety Use of Power Module

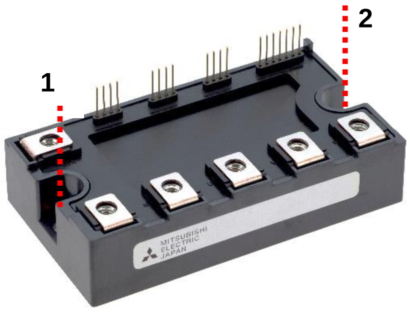
Unsuitable operation (such as electrical, mechanical stress and so on) may lead to damage of power modules.
Please pay attention to the following descriptions and use Mitsubishi Electric's IGBT modules according to the guidance.

	⚠ Cautions
During Transit	• Keep sipping cartons right side up. If stress is applied by either placing a carton upside down or by leaning a box against something, terminals can be bent and/or resin packages can be damaged. • Tossing or dropping of a carton may damage devices inside. • If a device gets wet with water, malfunctioning and failure may result. Special care should be taken during rain or snow to prevent the devices from getting wet.
Storage	• The temperature and humidity of the storage place should be 5~35°C and 45~75% respectively. The performance and reliability of devices may be jeopardized if devices are stored in an environment far above or below the range indicated above.
Prolonged Storage	• When storing devices more than one year, dehumidifying measures should be provided for the storage place. When using devices after a long period of storage, make sure to check the exterior of the devices is free from scratches, dirt, rust, and so on.
Operating Environment	• Devices should not be exposed to high humidity environment (incl. condensation), organic solvents, corrosive gases, explosive gases, fine particles, or corrosive agents, since any of those can lead to a serious accident.
Flame Resistance	• Although the epoxy resin and case materials are in conformity with UL 94-V0 standards, it should be noted that those are not non-flammable.
Electrostatic Measures	It is necessary to take precautions against the device rupture caused by static electricity. In case of IPM, It is also necessary to take precautions against the device rupture caused by static electricity, even though IPM's emitter and corrector terminals aren't exposed to the outside of its case directly. (1) Precautions against the device rupture caused by static electricity Static electricity of human bodies and cartons and/or excessive voltage applied across the control terminals may damage and rupture devices. The basis of anti-electro static build-up and quick dissipation of the charged electricity. * Containers that are susceptible to static electricity should not be used for transit nor for storage. * Never touch the control terminals with bare hands and use the glove. Glove and cloth should be anti-electrostatic * Always ground the equipment and your body during installation. It is advisable to cover the workstation and it's surrounding floor with conductive mats and ground them. Precaution for installation should be cared after taking the module from carton box. * It should be noted that devices may get damaged by the static electricity charged to a printed circuit board if the control terminals of the circuit board is open. * Use low voltage (12V ~ 24V) soldering irons for semiconductor, and ground the solder iron tip. (2) Precautions when the control terminals is open * Voltage should not be applied across collector - emitter when the control terminal is open. * The control terminals should be shorted before removing a device from a unit.
Anti-electrostatic Measures	* When conducting acceptance inspection (saturation voltage test etc.) such as applying voltage to the control terminal, it is accumulated electric charge between each terminal and the GND terminal before returning to the packing box or storage (conductive) container after the test is completed. Please discharge with high resistance (about 10 kΩ).
Connection Method	*When mounting the module, do not apply excessive stress to the screw terminal (structure) part. It may result in breakage of the terminal structure itself and the mating part of the terminal structure and case. *It is necessary to be care not to apply excessive stress and deform main and control pins when inserting into the printed circuit board using printed circuit board etc.

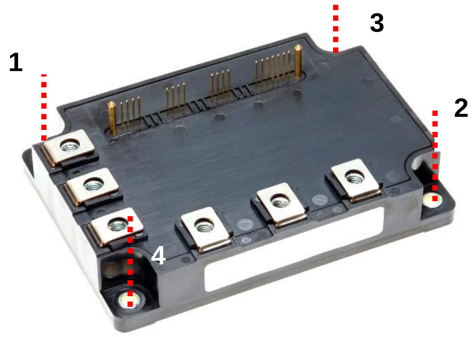
⚠ Cautions

Mounting

When mounting a module on a heat sink, a device could get damage or degrade if a sudden torque ("one side tightening ") is applied at only one mounting terminal. Shown in following figure is the recommended torquing order for mounting screws.



a) Two point mounting type
Temporary tightening :1→2
Final tightening :2→1

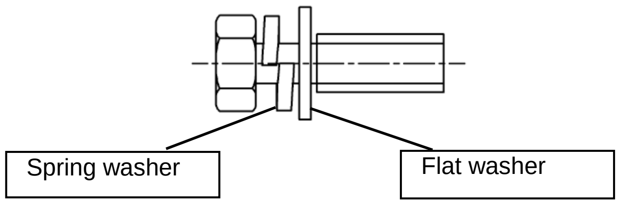


b) four point mounting type
1→2→3→4
4→3→2→1

The torquing order for mounting screws

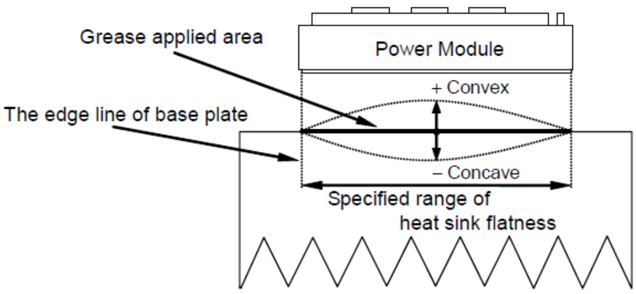
*:Temporary tightening torque should be set at 20~30% of maximum rating.

*:Please tighten a screw with spring washer and flat washer. (Recommendation)



example : screw with spring washer and flat washer.

Also, care must be taken to achieve maximum contact (i.e. minimum contact thermal resistance) for the best heat dissipation. The flatness of heat sink(es) where a module is mounted should be as follows.
-50 μm ~ +50 μm on a length of 100 mm
Also, the surface finish should be as follows.
Less than 10 μm of roughness on a length of 100 mm
Please apply good thermal conductivity grease (termed hereinafter called grease) for heat radiation to the contact surface of the module and heat sink evenly as follows.
+50 μm ~ +100 μm
Grease on the contact surface prevents the corrosion of the contact surface. However, use the kind of grease that has a stable characteristic over the whole operating temperature range and does not change its properties for several years. A torque wrench shall be used in tightening mounting screws and tighten screws to the specified torque. Excessive torquing may result in damage or degradation of a device.

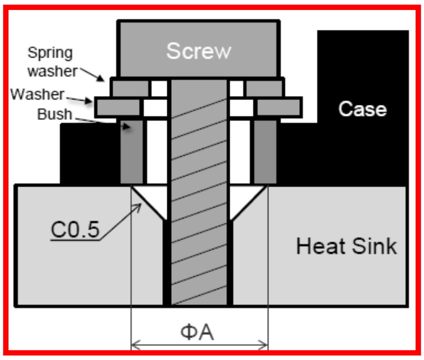


Heat Sink Flatness

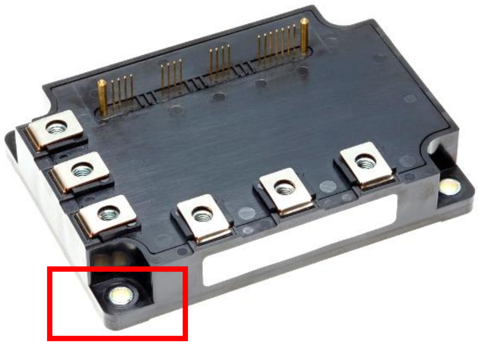
⚠ Cautions

Mounting

In the processing of screw holes of a heat sink where a module is mounted, it is necessary to secure the axial force of mounting screw (Screw loosening prevention) and prevent the stress concentration to case resin. Recommended maximum outer diameter(ΦA) for screw holes of a heat sink is as follows.



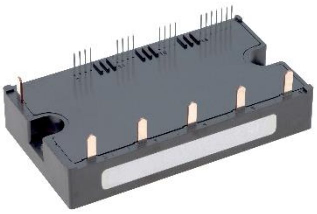
Section A



Section A

*Common for each screw holes

・A-PKG : Mounting screw size M4, Recommended ΦA(Max) = Φ5mm
G1A:A package, Main terminal Screw type (Straight layout)
G1AL:A package, Main terminal Screw type (L-shaped layout)
G1AP:A package, Main terminal Pin type (Straight layout)
G1APL:A package, Main terminal Pin type (L-shaped layout)



・B-PKG : Mounting screw size M5, Recommended ΦA(Max) = Φ6mm
G1B : G1B:B package, Main terminal Screw type

・C-PKG : Mounting screw size M5, Recommended ΦA(Max) = Φ6mm
G1C:C package, Main terminal Screw type

8. Installation of power module

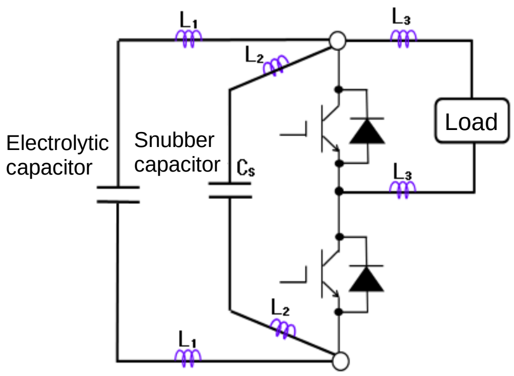
8-1. Installing capacitor

High di/dt will be occurred in the closed circuit from electrolytic capacitor during the switching operation. When this circuit layout is long, stray inductance becomes larger and the surge voltage (L*di/dt) will be biased to IPM in switching operation(turn on and turn off). When surge voltage exceed the maximum rating voltage of IPM, it causes damages or destruction of IPM.

There are the following methods to prevent this, it is common to use them in combination.

(1). Located the electrolytic capacitor as close as possible IPM. In addition, the inductance is reduced by disposing the reciprocating line in a laminate state and canceling the magnetic field.
(2). Use snubber capacitor located as close as possible IPM to bypass high frequency current and absolves the surge voltage
(3). Adopt low impedance electrolytic capacitor as smoothing capacitor

It is a general method to suppress the stray inductance (L1) of the main circuit as much as possible by (1) or (3), and, combination use (2) when the surge voltage is large. Regarding (2), if the stray inductance (L1) is large, the ringing behavior may increase due to the resonance between Cs and L1. In this case, ringing behavior can be suppressed by changing the value of Cs.



L1 :
Stray inductance between the electrolytic capacitor and IPM. It is necessary to make laminated bus-bar made of parallel plate with insulator and to cancel each other's magnetic field in round-trip.

L2 :
Stray inductance in the snubber capacitor. If this inductance is large, it will not absolve the surge voltage

L3 :
Stray inductance between the load and output terminal

8-2. Installation hints

Use a torque wrench for tightening and tighten to the required torque. If the tightening torque is too large, there is a danger of breakage or deterioration of IPM as well as one side tightening. Please install by hand tightening as much as possible. When tightening with an electric screwdriver etc., please extrude the extra grease by pushing the module against the heat sink before tightening, please slow down the fastening speed adequately and use low viscous grease. If fastening with high viscosity grease being caught in a large amount, the module may be deformed and it may be damaged. Also, if the screw is tightened in a tilted state, the case may be damaged.

Note)
The contact thermal resistance shown in the data sheet is a reference value determined from grease thickness, thermal conductivity and base plate area. Since it will change depending on the type and amount of grease, and heat sink condition, please select the proper grease and heatsink by actual evaluation.

8-3. Coating method of thermal grease (Example)

The coating method of thermal grease is introduced in this section. The thermal grease is called as grease in the following.

① Preparations: power module, grease, scraper or roller, electronic mass meter and gloves

* Thermal compound basically performs the same function as grease,
When using high viscous one, it is necessary stir before use so that it spreads over the whole base plate.

② Relationship between the coating amount and thickness is,

$$\text{Thickness of grease} = \frac{\text{amount of grease [g]}}{\text{base area of module}[\text{cm}^2] \times \text{density of grease}[\text{g/cm}^3]}$$

The recommended thickness of grease is approx..50μm~100μm.
this thickness is the initial value at the time of coating, after mounting, it varies depending on the base plate and heat sink flatness.

The amount of grease can be obtained as the following example.

For example : For case with size of 9.41×4.0cm (PM150CG1B065), density of grease is 2.65g/cm^3 can be calculated through the equation below.

$$50\sim100\mu\text{m} = \frac{\text{amount of grease } [g]}{37.64[\text{cm}^2] \times 2.65[\text{g/cm}^3]}$$

∴The amount needed is ≒0.5~1.0 [g]

③ Measure the mass of module
④ Measure the grease with the same amount as calculated
⑤ Coating the module base plate uniformly by using scraper or roller

Besides, there is a grease mask printing. any method can be used as long as the target thickness is uniform over the entire surface of the base plate of the power module.

⑥ When the grease that protrudes after installing the heat sink is remained, the effect of suppressing the secular change of grease on the contact surface may increase.

8-4. Connecting the Interface circuit

The control terminal of IPM is directly connected to control board (printed circuit board). By directly connecting the interface circuit of the IPM, the signal and power supply layout becomes shorter and the noise immunity improves. G1AP, G1APL type has a terminal structure to connect with control board by solder, the control terminal is tin plated. Other types can be connected to the control board with connectors. To reduce the contact resistance, the control terminals are plated with gold. The main terminals are connected by screws or solder. For connector specifications please contact the manufacturer.

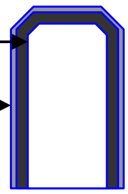
IPM type	Connection method and type name of connector
PM50CG1AP065, PM75CG1AP065 PM100CG1AP065, PM50RG1AP065, PM75RG1AP065 PM50CG1APL065, PM75CG1APL065, PM100CG1APL065, PM25CG1AP120, PM35CG1AP120 PM50CG1AP065, PM25RG1AP120, PM35RG1AP120 PM25CG1APL120, PM35CG1APL120, PM50CG1APL120	Main terminal Connect by solder. Control terminal Connect by solder. *Recommended soldering condition · Reflow ⇒ can not be applied. · Flow ⇒ Recommended: 260 °C within 10 seconds · Soldering iron ⇒ Recommended: 340°C within 10 seconds
PM50CG1A065, PM75CG1A065 PM100CG1A065, PM50RG1A065, PM75RG1A065 PM50CG1AL065, PM75CG1AL065, PM100CG1AL065, PM25CG1A120, PM35CG1A120 PM50CG1A065, PM25RG1A120, PM35RG1A120 PM25CG1AL120, PM35CG1AL120, PM50CG1AL120	Main terminal Connect by screw (screw:M4). Control terminal Connect by connector. **DF10-31S-2DSA(78), or DF10-31S-2DSA(72)** (HIROSE ELECTRIC CO., LTD) **SERIES 18020 *** **IMSA-18020S-19A-GFN4 or IMSA-18020S-19B-GFN4** (IRISO ELECTRONICS CO., LTD)
PM50CG1B065, PM75CG1B065 PM100CG1B065, PM150CG1B065 PM200CG1B065, PM50RG1B065, PM75RG1B065 PM100RG1B065 PM150RG1B065 PM200RG1B065, PM25CG1B120, PM50CG1B120 PM75CG1B120, PM100CG1B120 PM25RG1B120, PM50RG1B120 PM75RG1B120, PM100RG1B120	Main terminal Connect by screw (screw:M4). Control terminal Connect by connector. **DF10-31S-2DSA(78), or DF10-31S-2DSA(72)** (HIROSE ELECTRIC CO., LTD) **SERIES 18020 *** **IMSA-18020S-19A-GFN4 or IMSA-18020S-19B-GFN4** (IRISO ELECTRONICS CO., LTD)
PM200CG1C065, PM300CG1C065 PM450CG1C065, PM200RG1C065, PM300RG1C065 PM450RG1C065 PM100CG1C120, PM150CG1C120 PM200CG1C120, PM100RG1C120、 PM150RG1C120 PM200RG1C120	Main terminal Connect by screw (screw:M5). Control terminal Connect by connector. **DF10-31S-2DSA(78), or DF10-31S-2DSA(72)** (HIROSE ELECTRIC CO., LTD) **SERIES 18020 *** **IMSA-18020S-19A-GFN4 or IMSA-18020S-19B-GFN4** (IRISO ELECTRONICS CO., LTD)

* SERIES 18020
Adopting a floating structure, it is easy to insert even when inserting multiple IPMs at the same time with good insertability.

8-5. Terminal of IPM

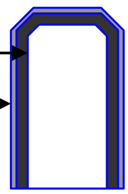
(1) The material of control terminal of IPM (A package screw type, B package, C package)
The material and the metal finishing of the control terminal of IPM are shown below.

Main material		Brass
Surface Treatment	Substrate	Nickel (Ni) thickness = 1～5.5 um
	Surface	Gold (Au) thickness = 0.05～0.25 um



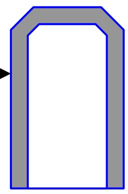
(2) The material of control terminal of IPM (A package pin type)
The material and the metal finishing of the control terminal of IPM are shown below.

Main material		Brass
Surface Treatment	Substrate	Nickel (Ni) thickness= 0.5～1 um
	Surface	Tin (Sn) thickness= 2～6 um



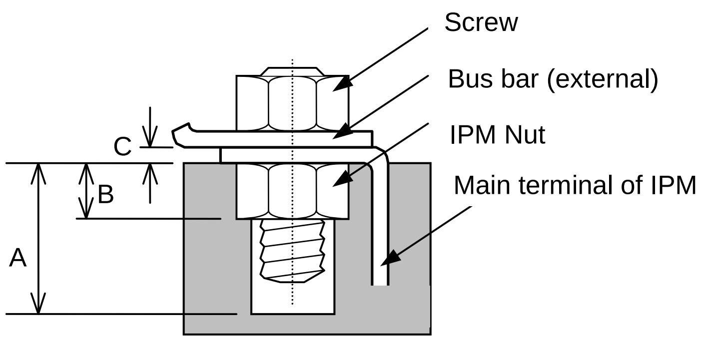
(3) The material of main terminal of IPM
The material and the metal finishing of the control terminal of IPM are shown below.

Main material		Copper
Surface Treatment	Surface	Nickel (Ni) thickness= 2～6 um



(4) The main terminal of IPM (Screw type)

The structure of main terminal of IPM are shown bellow.



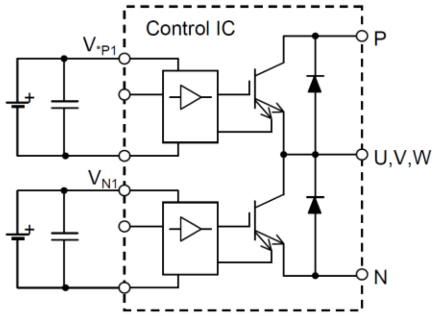
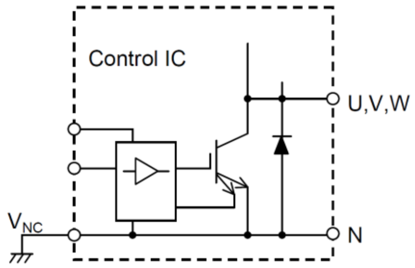
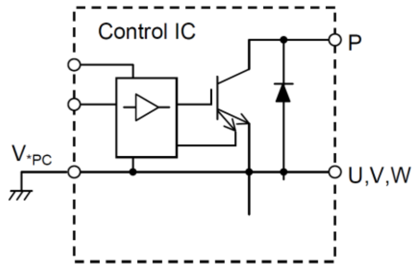
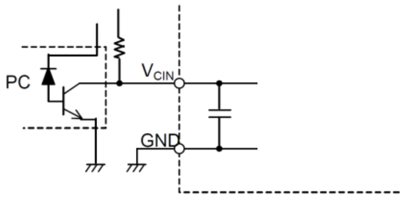
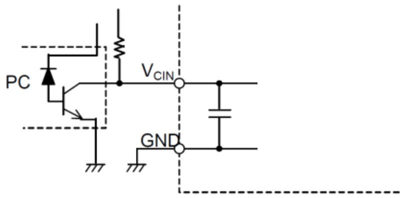
Package	Screw	Deepness of Screw Hole	Thickness of IPM Nut	Thickness of Main Terminal
		Mark A (mm)	Mark B (mm)	Mark C (mm)
A,B package	M4	typ=5.7/min=5.4	typ=3.2	typ=0.8
C package	M5	typ=6.4/min=6.1	typ=4.0	typ=0.8

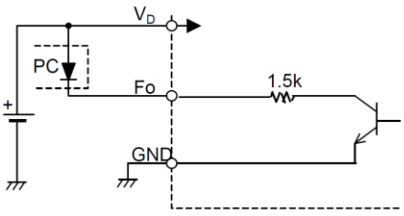
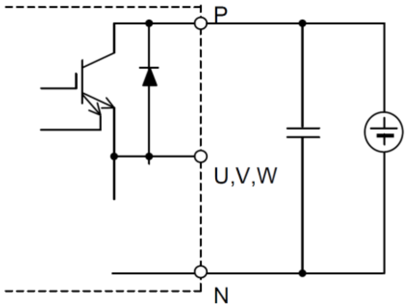
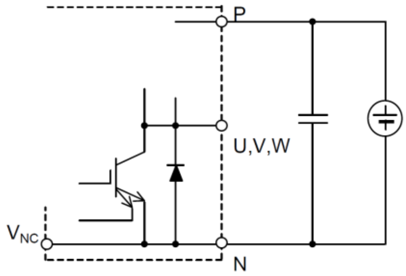
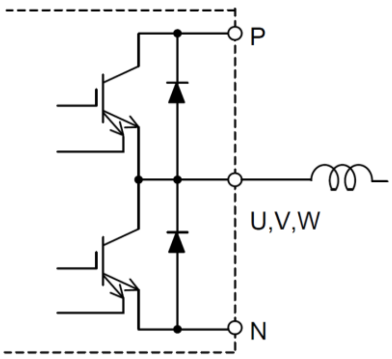
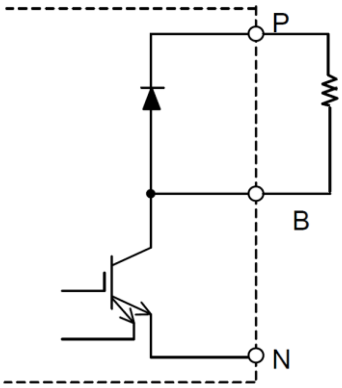
If the screw is longer than the screw hole depth A, the case may break and contact the PCB inside the IPM and cause destruction. Please choose the appropriate screw from the above dimensions. Also, please use spring washer as necessary for tightening.

(5) The guide pin of IPM
The guide pin of the control terminal is metal. However, this guide pin is molded by plastic and isolated, and it is not connected anywhere.

9. Using IPM

9-1. Instruction of the symbol for IPM terminal

No	Name	Symbol	Block diagram	Operation (Description)
1	Power -supply	V_D V_{UP1} V_{VP1} V_{WP1}		Power supply terminal of control IC built in IPM. Apply individually insulated power supply to both N side (lower arm) and P side (upper arm). In the G1 series, a total of four independent power supplies are required. With DC 12.7V or less, UV protection works. In this state, outputting the Fo signal and input signal does not work. At DC 16.5V or higher, short circuit protection can not be guaranteed. The typical value is DC 15V. Please use a capacitor with good frequency response close to the IPM terminal to avoid malfunction due to noise and power supply ripple.
2	Ground	V_{NC}		This is the N side power supply GND. In the G1 series, it is common to the N side 3 phases. Since This GND is reference potential for the control power supply, please do not let the main current flow into GND to avoid the influence of noise,. Please do not connect this terminal and N terminal with the pattern on the board. it is connected to the N terminal of the inverter GND internally,. However, due to parasitic inductance of the pattern, a potential difference may occur between N - VNC during actual operation.
		V_{UPC} V_{VPC} V_{WPC}		It is the power supply GND of each phase P side. In order to improve noise immunity, please reduce the power supply impedance as much as possible. Please insulate each phase of U, V, W.
3	Control -signal	U_P V_P W_P U_N V_N W_N		Input terminal for controlling switching operation for IPM. It operates with voltage input. Normally, it is used with connecting a pull-up resistor to the control power supply and the photo coupler externally . Since it is sensitive to noise, please pay attention to design as the shortest control signal pattern. Also, connect a capacitor with good frequency response between power supply and GND as close as possible IPM.
4	Brake Control -signal	Br		This terminal is used with R_{XX} (RG1A) type. The purpose of this terminal is to prevent increase in P-N voltage, which is caused by regenerative current produced when AC motor decelerates. Normally, it is used with connecting a pull-up resistor to the control power supply and the photo coupler externally . Since it is sensitive to noise, please pay attention to design as the shortest control signal pattern. Also, connect a capacitor with good frequency response between power supply and GND as close as possible IPM.

5	Fault -output	F_O		It is an output terminal indicating the abnormal state of IPM. There are three error modes, over-temperature, short circuit, and control supply voltage drop. It can be identified by detecting the output Fo signal period. The terminal is an open collector(drain) with series connected resistors. LED of photo coupler can be directly connected between this terminal and VD.
6	Inverter Power -supply	P		Power supply terminal to inverter. In usual applications, connect this terminal to positive (+) line after rectified AC line. Internally connected to collector of upper arm IGBT. In order to suppress surge voltage caused by stray inductance, connect a electrolytic capacitor as close as possible P and N terminals. It is also effective to add a snubber capacitor with good frequency response.
7	Inverter -ground	N		Power supply ground of inverter. In usual applications, connect this terminal to ground (-) line after rectified AC line. Internally connected to emitter of lower arm IGBT. It is also connected to the control GND V_{NC}. The potential difference may occur between V_{NC} and N during actual operation due to the stray inductance inside of IPM.
8	Output	U V W		Inverter output terminal. Usually, connect a load such as an AC motor. Internally, it is connected to the midpoint of IGBT composed of half bridge (emitter of P side IGBT, collector of N side IGBT).
9	Brake -output	B		This terminal is used with R_{XX} (RG1A) type. The purpose of this terminal is to prevent increase in P-N voltage, which is caused by regenerative current produced when AC motor decelerates. Normally, connect a power consumption resistor (brake resistor) to P side. It is designed on regenerative current for inverter operation with AC motor. Current rating of Brake is 50% of IGBT current rating in U, V, W inverter part (*Depends on rating) It can not be used for applications in which excessive current flows due to special control and switching at high frequency.

9-2. Function of the IPM

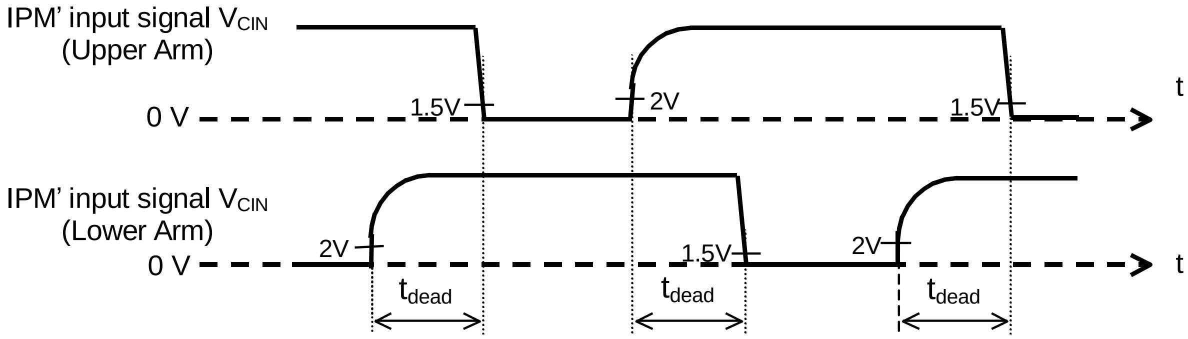
Function	Symbol	Description
Nominal operation	-	・Off-level input signal (V_{CIN} >$V_{CIN(off)}$) drives IGBT off, On-level input signal (V_{CIN} <$V_{CIN(on)}$) drives IGBT on.
Short circuit Current Protection	SC	・IPM monitors forward collector current of each IGBT by current sensor built in IGBT chip. If the current exceeds SC trip level, IPM identifies it as short circuit and turn off the IGBT with soft shutdown. ・In case that either IGBT on lower arm have short-circuited, IPM turn off all lower IGBTs (U_N,V_N,W_N and Br) with soft shutdown. ・The fault signal is output for the duration of $t_{FO(SC)}$ when IPM detecting the short circuit.
Over Temperature Protection	OT	・IPM monitors each IGBT chip surface temperature. If the temperature exceeds OT trip level, IPM identifies it as over temperature and turn off the IGBT with soft shutdown. ・In case that either IGBT on lower arm have over temperature state, IPM turn off all lower IGBTs (U_N,V_N,W_N and Br) with soft shutdown. ・The fault signal is output for the duration of $t_{FO(OT)}$ when IPM detecting the over temperature.
Under-Voltage Lockout Protection	UV	・IPM monitors control power supply voltage of each power supply. If the control power supply falls UV trip level and continues with it for a certain duration, IPM turns off IGBT with soft shutdown. ・In case that N side power supply has under voltage state, IPM turn off all lower IGBTs (U_N,V_N,W_N and Br) with soft shutdown. ・The fault signal is output for the duration of $t_{FO(UV)}$ when IPM detecting the Under voltage.
Soft Shutdown	-	・The gate voltage of the IGBT is gradually turn off in order to suppress the surge voltage when each abnormal state is detected and IPM protect them.
Fault Output	F_O	・During SC, OT, UV protection, it conducts for the period corresponding to each error. A resistor (1.5kΩ) is connected inside IPM in series.

* Refer to 9-4 for the timing chart of each protection.

Dead time (tdead)

It is necessary to set upper and lower arm dead time for each arm input signal of IPM.

There is no function to automatically generate it inside of IPM. The dead time of IPM is measured at the control terminal of IPM, and the dead time of the photo coupler is not considered.



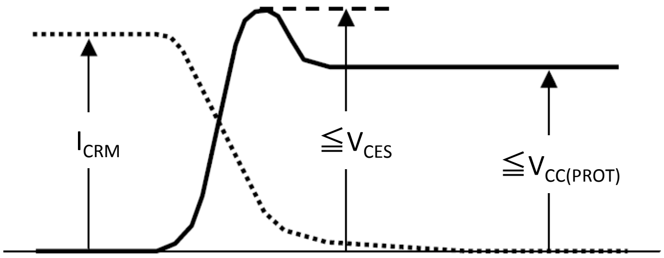
1.5V: Input on threshold voltage Vth(on) typical value, 2V: Input off threshold voltage Vth(off) typical value
*
Vth(on) and Vth(off) are the minimum threshold voltages required to turn on or off. VCIN (on) ≤ 0.8 V and VCIN (off) ≥ 9.0 V for the input signal voltage is recommended to ensure stable ON and OFF states.

9-3. Safe operating area for IPM

IPM has built-in gate drive and protection circuit, so IGBT is protected from many abnormal modes except overvoltage. Since IPM has built-in protection circuit, SOA (Safe Operating Area) like non-intelligent IGBT module is not defined. The IPM protection circuit is designed to satisfy the SOA of the IGBT chip. The safe operating area of IPM is defined as follows.

(1) Turn off switching SOA
Normally, switching SOA of IGBT is defined by maximum voltage (withstand voltage) and maximum current. IPM has protection function and collector current is limited by SC protection. On the other hand, as for the voltage, it is necessary that the surge voltage by the inductance inside the IPM and the stray inductance between the IPM and the electrolytic capacitor have to be within the withstand voltage (VCES) of IPM.

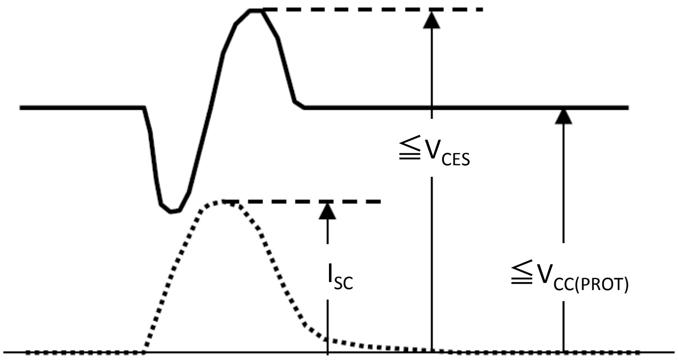
Condition : VCES and VCC(prot) ≦ ratig Voltage, VD = 13.5V~16.5V, Tvj = 125°C



Turn-off Switching SOA

(2) Short Circuit SOA
IPM has built-in SC protection circuit. The short-circuit current is determined by the SC protection level of the IPM and the inductance of the short-circuit wiring, so the short circuit current that cause destruction does not flow to the IPM. On the other hand, as for the voltage, it is necessary that the surge voltage by the inductance inside the IPM and the stray inductance between the IPM and the electrolytic capacitor have to be within the withstand voltage (VCES) of IPM. It is necessary to suppress the surge voltage by the main circuit with a snubber capacitor. The IPM short circuit SOA is defined as shown below.

Condition : VCES and VCC(prot) ≦ rating Voltage, VD = 13.5V~16.5V, Tvj = 125°C

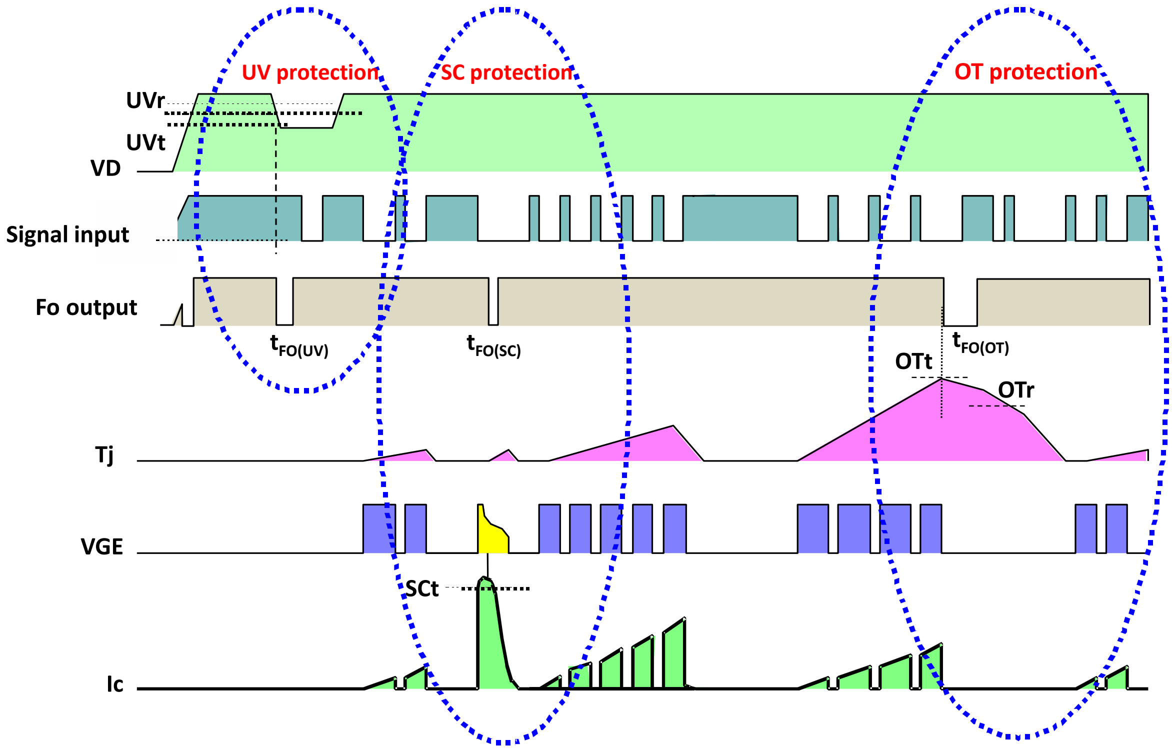


Short circuit SOA

(3) Operation in active region
IPM has a control power supply voltage drop protection and turns off the IGBT with the power supply voltage VD = 12.7 V or less (12.0 V typ.). IGBT can not operate with low gate voltage like non-intelligent. IPM recommends using the power supply voltage between 13.5V and 16.5V. When operating within the recommended voltage range and within the rated current, IPM is designed not to operate in active region.
For SC, UV, OT, on the P side, only the IGBT of the phase where the error occurred is turned off individually. At this time, each phase on the N side switching is available state. On the other hand, on the N side, all IGBTs on the N side 3 phases (+ brake) are turned off regardless of the phase in which the error occurred. At this time, each phase on P side switching is available state. Refer to 9-4 for the sequence of an error occurs.

9-4. Fault signal of IPM

Three types of protection operate according to the cause of errors in IPM. SC (short circuit protection), OT (over temperature protection), UV (control power supply voltage drop protection). IPM is designed to operate various protection against non-repetitive errors.
When designing the system using IPM, do not apply constantly (repeatitive) stress exceeding the maximum rating. When a Fo signal is output, it is necessary to stop the operation by stopping the control input signal within 1 ms (tFO (SC) min) without relying on the IPM protection. When restarting operation, remove the error cause and set an interval of about 10 seconds. Since IPM does not eliminate the cause of errors, it is necessary to eliminate error on the system side. (Even if the fault signal is reset, normal operation after resetting is not guaranteed.)



(1) Error mode identification
In the conventional IPM, the Fo signal is output until the error state is reset. Please identify the error contents with the following value since the Fo output duration is different in the G1 series. When the error state continues, the input signal will not be accepted and will keep off state.

Symbol t_{FO}	Parameter	Condition	Criteria Min	Criteria Typ	Criteria Max	Unit
$t_{FO(SC)}$	SC Fo output pulse width	Tc=-20～125°C *1	1.0	2.0	2.7	ms
$t_{FO(UV)}$	UV Fo output pulse width		2.8	4.0	5.4	
$t_{FO(OT)}$	OT Fo output pulse width		5.5	8.0	10.9	

*1
Fault output is given when the internal SC, OT & UV protections.
Fault output by SC, OT, UV is given from upper and lower arm
Fault output by SC, OT, UV is given by pulse

(2) Protection

Control Power Supply Under-Voltage (UV)
UV prevents IGBT's thermal destruction from VCEsat loss increase caused the control power supply voltage drops. It detects the control voltage and the IGBT chip to forcibly turn off when the voltage drops below the trip voltage (UV trip level). To detect UV, there is a filter circuit of approx.10us in the control IC, so it is necessary that the UV level continues for about 10μs or more. If a steep ripple voltage is applied to the control power supply, the internal control IC malfunctions and the power supply voltage drop protection may operate. Please supply a stable power supply with less noise. When control power supply voltage becomes over reset voltage (UV reset level) with hysteresis, protection is reset. In this period, fixed fault signal is output by 1 pulse. The Fo pulse width is typ = 4ms of the internal timer circuit.

Over Temperature (OT)
OT directly detects the chip surface temperature of the IGBT chip and turns off the IGBT when it exceeds the trip temperature (OT trip level). There is a filter circuit by a capacitor to OT. When OT falls below the reset temperature with hysteresis (OT reset level), the protection is reset. In this period, fixed fault signal is output by1 pulse. The Fo pulse width is typ = 8ms of the internal timer circuit.
The cause of over temperature protection is a continuous overload or abnormality of the surrounding environment. It may not be able to fully protect with transient overload (repeated overload in a short time). Please ensure thermal design of system including such overload.

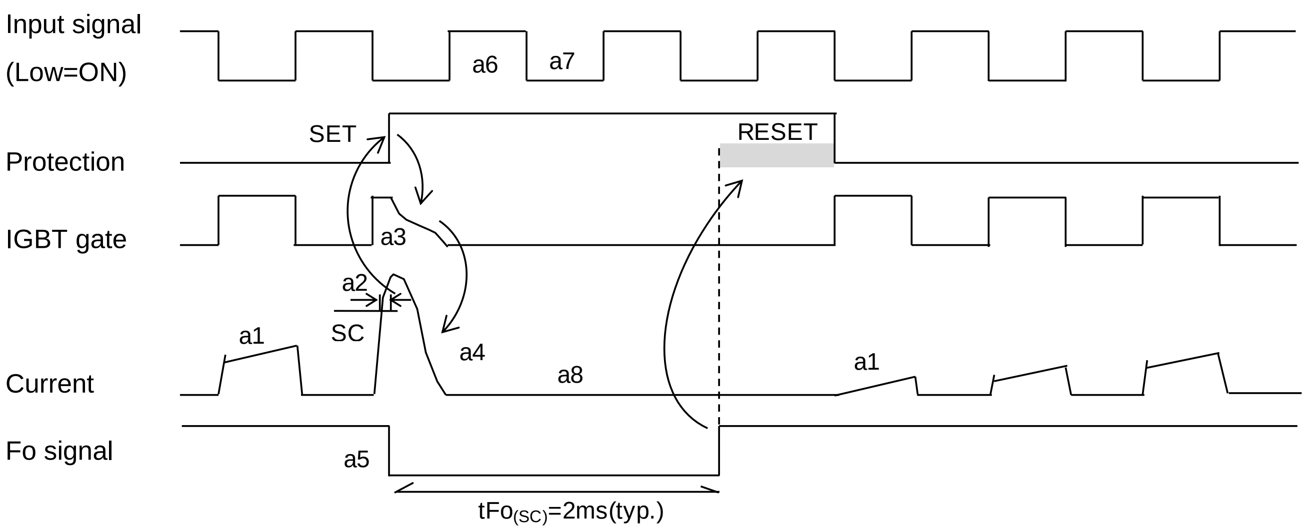
Short Circuit (SC)
SC detects the forward collector current of the IGBT in order to prevent short circuit failure and turns off the IGBT when the current exceeds the setting current of the SC trip level.
In case of short-circuit ,SC protection sequence is detection => protection => shutdown. The protection latch period is constant period(typ. 2 ms), and it does keep off after this latch period. For this reason, if the PWM signal continues to be input at the control terminal, it is reset after the latch time (Fo reset) and is switched again. If short circuit condition continues, short circuit and protection are repeated. The IGBT chip is used close to its capability in this kind of operation, it will cause excessive chip temperature rise and thermal destruction.

Caution) The SC does not detect freewheeling current flowing in the freewheel diode (FWD) connected anti-parallel to the IGBT. The IPM input terminals are turned ON at the same time by the external noise such as lightning surge and the malfunction of signal source. It is assumed that it will happen about several times during inverter life. The number of repetitions of short circuit is not guaranteed.

(3) Protection sequence

SC protection sequence

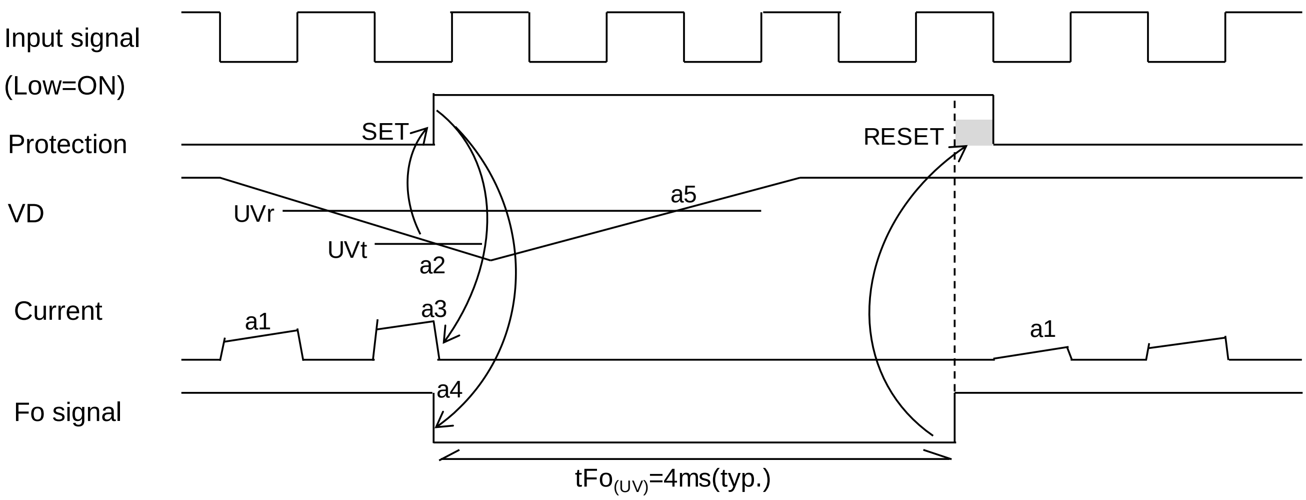
a1. Normal operation＝IGBT on=current flow
a2. Short circuit detection (SC trip)
a3. IGBT soft shut down
a4. IGBT turn off gradually
a5. Fo timer start・・・・constant pulse width：tFo(SC)(typ.2ms)
a6. Input signal="H"=off
a7. Input signal="L"=on
a8. IGBT keep off state



SC protection sequence

UV protection sequence

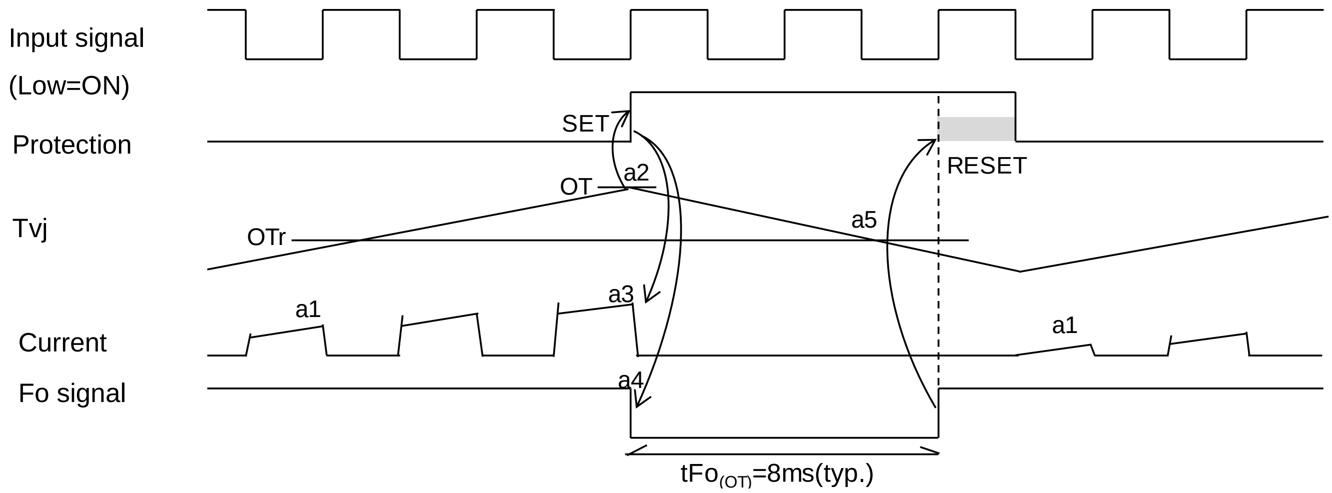
a1. Normal operation＝IGBT on=current flow
a2. UV detection (UVt) ←include 10μs noise filter
a3. IGBT off ←keep off state regardless input signal level
a4. Fo timer start・・・・constant pulse width：tFo(UV)(typ.4ms)
a5. UV reset(UVr) ←include 10μs noise filter



UV protection sequence

Over temperature protection sequence

a1. Normal operation＝IGBT on=current flow
a2. Over temperature detection (OTt) ←include noise filter
a3. IGBT off ←keep off state regardless input signal level
a4. Fo timer start・・・・constant pulse width：tFo(OT)(typ.8ms)
a5. Over temperature reset(OTr) ←include 10μs noise filter

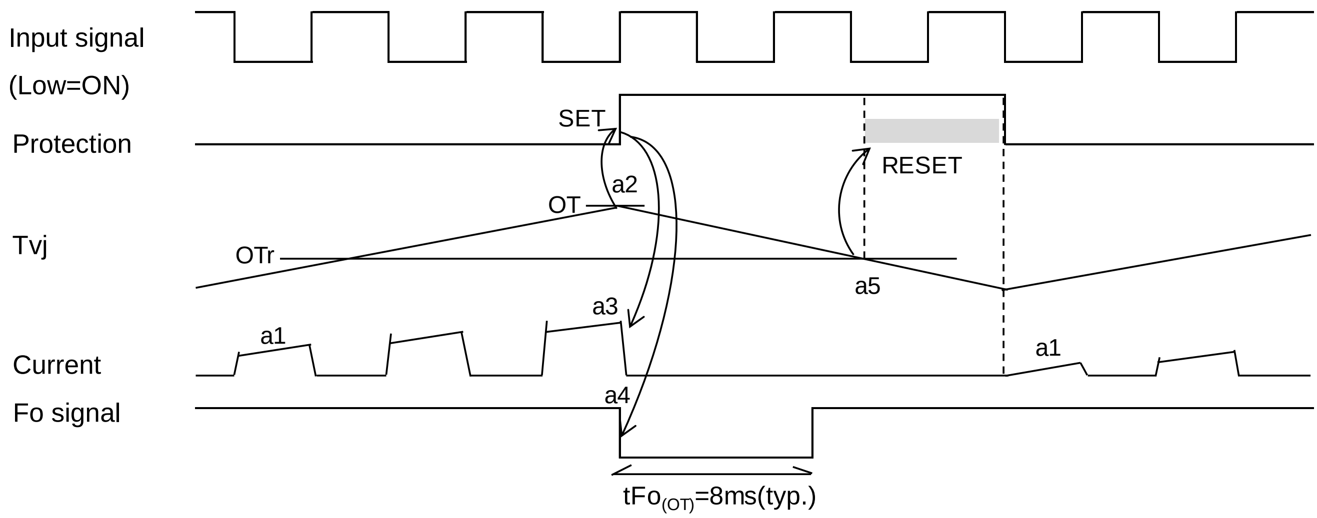


OT protection sequence

In case of continue error state

When he error condition continues for a time period tFo, the fault output pulse is reset. However, the protection state will continue until the error condition is reset. Below is an example of a case where the error state continues longer than the OT fault output pulse width (tFo (OT)).

a1. Normal operation＝IGBT on=current flow
a2. Over temperature detection (OTt)
a3. IGBT off
a4. Fo timer start・・・・constant pulse width：tFo(OT)(typ.8ms)
a5. Over temperature reset(OTr)



In case of continue error state (tFO < error state)

9-5. Interface Circuit Requirements

Since IPM switches high voltage at high speed, noise (high dv / dt) occurs. For insulation of the input signal, a photo coupler is usually used. Depending on the photo coupler selection, the photo coupler may malfunction due to high dv / dt caused by IPM. In order not to cause malfunction of the photo coupler, patterning layout is important. Pattern distance and arrangement from the power line are important so that the photo coupler output is not affected by high dv / dt. Precautions on pattern design of the interface circuit are shown below.

Interface Circuit layout Guidelines

a) Ensure insulation between the primary side and the secondary side of the control signal (normally using photo coupler) and between each phase (N, U, V, W). In some cases, it is necessary to ensure the insulation distance by placing a slit in the board, etc., keeping the distance between the pattern.

b) Insulation between each power supply (N, UP power supply, VP power supply, WP power supply) is required. In some cases, it is necessary to ensure the insulation distance by placing a slit in the board, etc., keeping the distance between the pattern.

c) IPM control (input) signal pattern (between photo coupler output and IPM input terminal) should be connected as short as possible. When the pattern is long, it is affected by noise, IPM may identify it as ON signal and the IGBT turns on. The pattern distance is ideally approx. 2 cm or less.

d) Connect a capacitor with good frequency response such as a ceramic capacitor between the control power supply terminals and photo coupler close to the IPM terminal and the photo coupler. Please absorb the noise generated by the switching of the IGBT and the power supply circuit so that the control power supply of the IPM does not fluctuate.

e) Provide a shielding layer on the printed circuit board and suppress the influence on the control system by dv / dt. In particular, when the power line (main circuit pattern and P side control power supply pattern) crosses the control line pattern, the control line may malfunction due to the influence of dv / dt due to the parasitic capacitance of the board.

f) Select the photo coupler used for the IPM input terminal with high speed type and high CMR.
(Open collector type is recommended)
tPLH, tPHL <0.8 μs
CMR> 10 kV / s @ VCM = 1500 V
Normally, connect a decoupling capacitor of approx. 0.1 μF near the photo coupler.

g) In order to suppress the influence of noise, it is necessary to design lower impedance by setting the pull-up resistance of the input signal (photo coupler output) as low as possible. Also, set the pull-up resistor and input current IF of the photo coupler so that IPM signal on state VCIN(on) can be secured when the photo coupler is ON state.
Note) Reducing the pull-up resistor too low will affect the lifetime of the photo coupler. Please take into consideration the lifetime of the photo coupler.

h) If there is a phase not to be used, supply 15 V control power to the unused phases and pull up the Fo and input terminals to 15V of each.

i) Pull up to the 15V power supply even if not using the Fo terminal.

j) The applied voltage to each control terminal of IPM should be less than the maximum rated voltage including surge ripple etc. Also, it is necessary to design so that negative voltage is not applied to the control terminal. It may cause malfunction or destruction.

9-6. Control power supply of IPM

(1)The control power supply

The control power supply voltage range should be within the limits shown in the specifications.

Control power supply voltage (V_D)	Operation behavior
0~4.0	It is the same situation as no power supply. Malfunction (ON) may occur due to external noise. Control power supply under voltage protection (UV) does not operate and Fo is not output
4.0~12.7	Even if the control input signal is input, the switching operation is not available. Control power supply under voltage protection (UV) works and outputs Fo
12.7~13.5	Switching operation is available. However, since it is out of the recommended condition, both VCEsat and switching time specified in the IPM specifications will deviate from its value, the power loss will increase, and the junction temperature will rise.
13.5~16.5	**It operates normally. It is recommended condition.**
16.5~20	Switching operation is available. However, it is out of the recommended condition. At the time of short circuit, its current peak becomes too large and it may broke caused exceed the chip capability.
20.0~	The control circuit in the IPM and the IGBT gate part may be broken.

・ Specifications for Ripple Noise

If high frequency noise is superimposed on the power supply line of the control IC, the IC malfunctions and outputs Fo, and furthermore the output may stop (gate shut down). In order to avoid this unintentional off, design the power supply circuit should be designed so that the fall slope of the noise becomes lower than ± 5 V / us and the amplitude of the ripple voltage becomes lower than 2V.

Limit: $\frac{dv}{dt} \le \pm 5V/us$, $Vripple \le 2Vp-p$

The noise appearing on the power line is high frequency.
(pulse width < approx. 50ns or less, pulse height < approx.5V or less).
If Fo is not output, it can be ignored the noise normally, but it is preferable that the control power supply has a lower impedance, so pay attention to the pattern layout. It is effective that using electrolytic capacitors and decoupling capacitors with good frequency response as close as possible IPM for countermeasures against malfunction.

・Sequence of control power supply starting up and shutting down

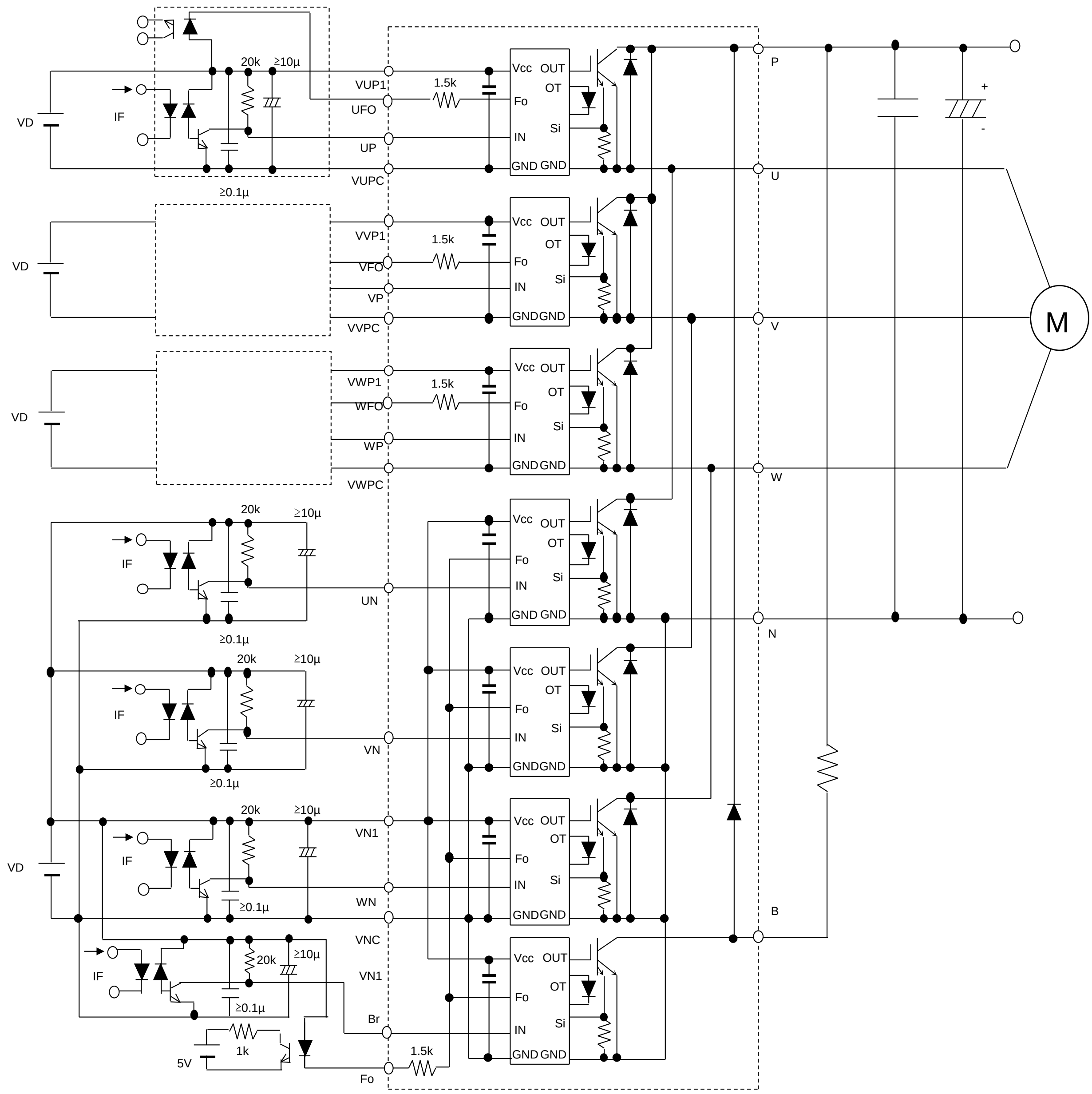
Control power supply VD should be started up prior to the main power supply (P-N supply).
Control supply VD should be shut down after the main power supply (P-N supply).
If the main power supply is started up before the control supply start up, or if the main power supply remains after control power supply is shut down, external noise might cause the IPM malfunction.

· Required number of control power supply

For the P side (upper arm), use the control power supply insulated from all three phases. Since the N side (lower arm) can be used one power supply common to 3phase and the brake part, a total of four isolated control power supplies are required. Also, when using multiple IPMs on the same bus line (PN), use 4 control power supplies for each IPM. If N side power supply is used in common by multiple IPMs, there is a possibility of malfunction or destruction.

9-7. Applications of IPM G-series to Motor drive

example）7in1 PM**RG1A065、 PM**RG1A120



Notes for stable and safe operation;

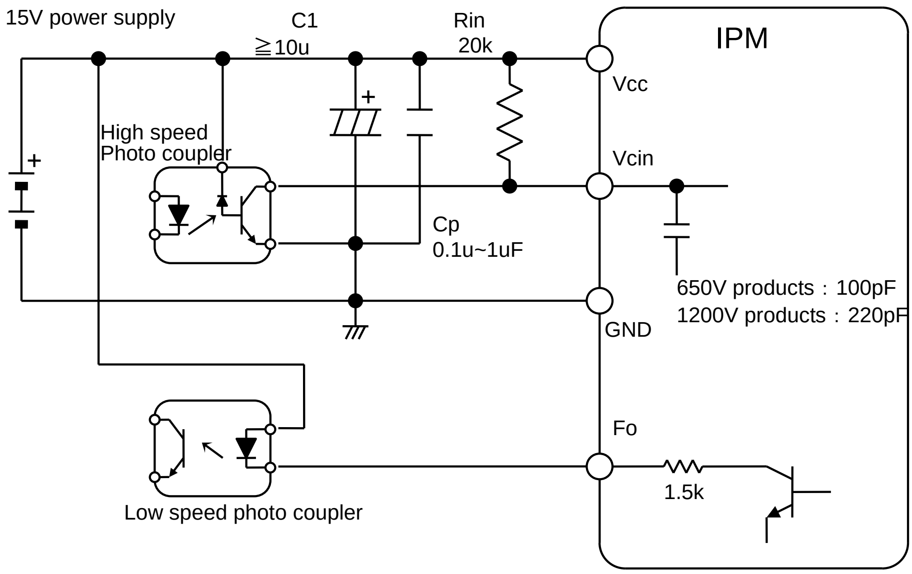
- Make the pattern between the photo coupler and the IPM terminal as short as possible, and make a pattern layout that does not increase the stray capacitance between the primary and secondary side of the photo coupler.
- High speed photo coupler: tpLH, tpHL ≤ 0.8 us, please use high CMR type. Depending on the application of the brake part, also a low speed photo coupler can be applied. In this case, the pull-up resistor must be selected appropriately according to the specifications of the low speed photo coupler. Also, please use pattern with IPM as short as possible and layout with minimum stray capacitance.
- Low speed photo coupler：CTR＞100%
- Use each control power supply with 4 insulated ones with small Instantaneous fluctuation independently. Also, please use a capacitor with low impedance for high-frequency close to each control power supply terminal to minimize the transient voltage fluctuation as much as possible.
- Suppress the surge voltage by making the DC bus between P and N as low impedance as possible and by connecting a snubber capacitor between the P and N terminals of the module.

9-8. Interface circuit for IPM

(1) IPM has a built-in gate drive circuit and protection circuit. In addition to the power supply, an isolation device such as a photo coupler that insulates the control signal is necessary in actual design.

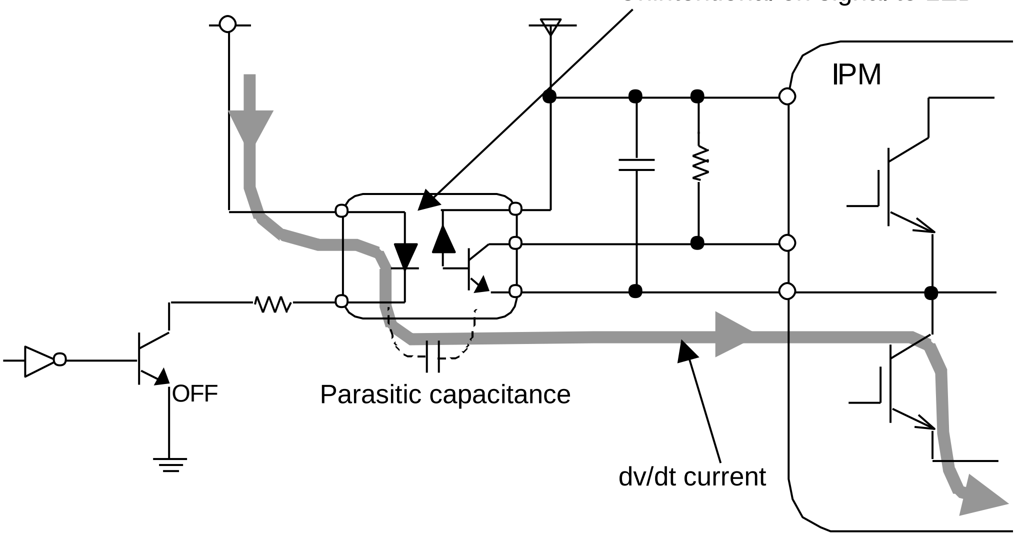
• input terminal	(1) High speed photo coupler, (2) pull-up resistor
	(3) capacitor
	(electrolytic type for stable power supply, and ceramic type for ripple elimination)
•Fo terminal	(4) Low speed photo coupler
•Control power supply	(5) Mutually insulated +15 V regulated power supply (4 power supplies).
	(the negative power supply for reverse bias for the IGBT module is unnecessary.)

(2) IPM Internal circuit diagram and interface circuit



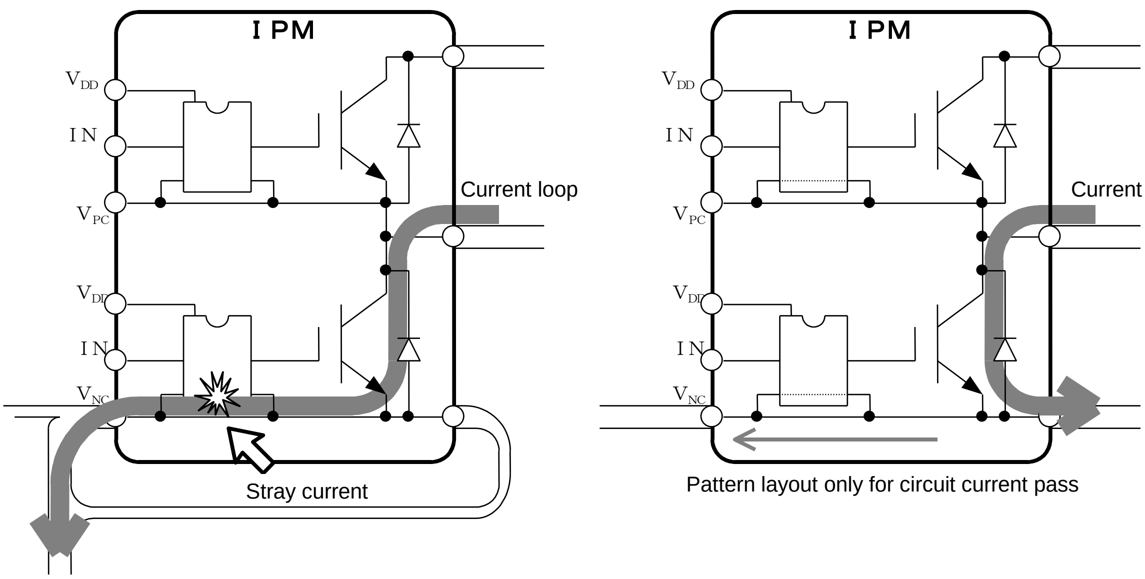
(3) IPM control input terminal
By applying voltage to this control input terminal, on / off switching of the internal IGBT is controlled.
Since the control signal does not drive the gate of the IGBT chip directly, even if the control input voltage is finely adjusted around the ON (OFF) threshold voltage, even if the pull-up resistance value is changed, the IGBT switching characteristics and DC characteristics do not change. From this relationship only with the IPM, if the threshold voltage is satisfied, the pull-up resistor value can be set arbitrarily.
However, if the pull-up resistance value is reduced, the primary and secondary currents of the photo coupler must be increased, which adversely affects the lifetime. Propagation delay also deteriorates. Therefore, the above values are taken as a representative example in consideration of the CTR / temporal characteristics of the photo coupler.
It is possible to reduce the pull-up resistance value to prevent noise malfunctions. In that case, please consider the relationship between the photo coupler characteristics including the lifetime and the relationship between the primary and secondary current (pull-up resistance value) after confirming with the photo coupler supplier.

(4) Precautions on using photo coupler
Photo coupler has parasitic capacitance between primary and secondary, and when dv / dt is given, dv / dt current flows through it. When this dv / dt current flows to the LED, it becomes an unintentional ON signal and the IPM may malfunction. When designing a photo coupler peripheral circuit, it is necessary to design against noise around the photo coupler and appropriate pattern design not to cause such malfunction.



Example of photo coupler malfunction

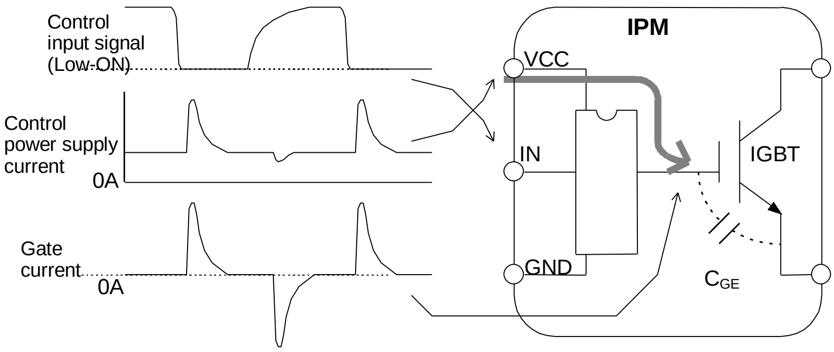
9-9. Other notes on the use of IPM
(1) About connection between control power supply ground (VNC / VPC) and output emitter (N or U / V / W)
It is recommended not to connect both terminals outside of the IPM. (because it is affected noise, It is recommended that the control current loop and main current loop should be designed to flow separately)
For example, both VNC and N terminals are connected inside the IPM, but please design a pattern outside the IPM so that the circuit current of the control part flows through VNC and the main current flows through N.
Since VNC is the reference ground of the control IC, when a stray current (a main current which should originally pass through N) flows, a potential difference occurs between the N-VNC by the stray inductance of the internal pattern, and the ground level may fluctuate and malfunction may occur.



(2) Parallel operation of IPM
IPM can not operate in parallel. IPM has a built-in gate drive circuit and protection circuit inside.
When IPM is operated in parallel, due to the deviation of switching time and protection timing, current may concentrate on specific IPM and it may cause destruction.

9-10. Design of control power supply for IPM

Since the IGBT gate used for IPM has an input capacitance (Cies = CGE + CCG), this current for charging (discharging) the gate flows every switching on (OFF) timing. Some IPMs have peak currents in over several amperes.



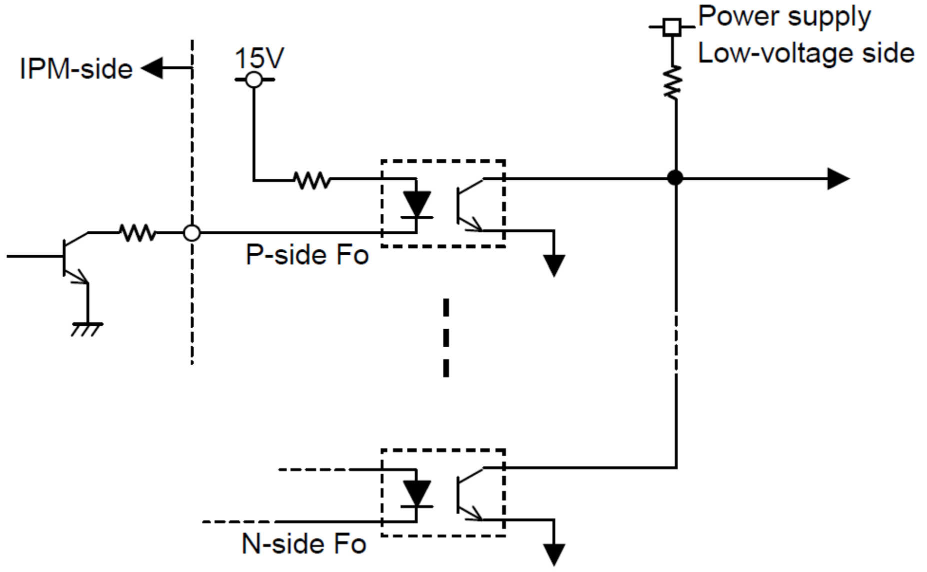
Furthermore, dV / dt current from the IGBT collector flows into the control power supply side when it turns off. Since this dV / dt current sometimes disturbs the control IC (control input terminal, Fo terminal), it may become the unintentional ON signal and cause arm short circuit, so It is necessary to design the control power supply with low impedance.

The control power supply circuit needs a capacity enough to supply and absorb these current fluctuations. Normally, this maximum current and impedance can be dealt with by the smoothing capacitor and ceramic capacitor for ripple elimination(bypass capacitor for high-frequency)., not the characteristic of the control power supply. Since not only the type of capacitor is affected but also the inductance of the pattern and layout, please select the type and capacity of the capacitor after verifying it with actual system design.

Regarding the design of the control power supply, it is recommend that power supply is designed safety in order to operate IPM within the recommended power supply voltage range from the relationship between the IPM circuit current and the carrier frequency shown in the data sheet. If the control power supply has insufficient capacity control power supply voltage drop protection (UV) may cause unintentional shut down.

9-11. Fo circuit

Since the Fo terminal has a built-in 1.5 kΩ resistor, an external resistor is unnecessary. Usually, it is directly connected to the photo coupler. If the Fo is not used, it is necessary to pull up to control power supply to prevent malfunction due to external noise.
The error circuit can be used in one common circuit by connecting the each collectors of low-speed photo coupler, However, error mode identification can not be performed when errors occur in multiple phases at the same time. A simple error circuit example is shown below.



Note when the Fo terminal on the P side is not used

If the Fo on the P side (upper arm) is not used, please pull up to each 15V power supply. Since the Fo terminal is an input / output dual-purpose terminal, the Low signal shut down IPM operation. SC protection in IPM can not be performed for ground faults because grand fault current flow through only P side, and it can not be detected by system side.
Since the protection of IPM assumes only non-repetitive errors, IPM may be destroyed when repetitive error state apply to IPM. Protection coordination is required on the system side for repetitive errors.

10. Power loss and junction temperature

In order to use the power module safely, it is necessary to confirm the power loss and the temperature under the actual operating conditions, and these must keep within the absolute rating.
When selecting a power module, please download and use simulation software from our website.

Download web site: http: //www.mitsubishielectric.co.jp/semiconductors/simulator/index.html

Please click "to register customer information" on the page, and after entering necessary information, the download page will be displayed.

*: Supported OS is Windows® 98SE or later Windows® only.

For the use of the software, please download the manual. Please refer to
"Power loss simulation Ver. *. **, User's manual, manual_en.pdf"

<u>Note when applying to thermal design</u>

1. It is necessary to consider the operating conditions which power loss is worst.
2. Temperature ripple due to output current cycle should be considered.
3. It is necessary to consider not only the maximum temperature but also power cycle and thermal cycle due to temperature swing.
4. The case temperature Tc needs to be measured and confirmed in the actual system.

11. Notice for safe Designs and using this appreciation note

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