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MITSUBISHI ELECTRIC

IPM L1/S1-series

APPLICATION NOTE

Sep. 2008

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1.Product Line-up

L1-series IPM

7pack (Inverter+ Brake)

600V (AC200)		1200V (AC400V)	
Screw type	Pin type	Screw type	Pin type
	PM50RL1C060		PM25RL1C120
PM50RL1A060	PM50RL1B060	PM25RL1A120	PM25RL1B120
PM75RL1A060	PM75RL1B060	PM50RL1A120	PM50RL1B120
PM100RL1A060	PM100RL1B060	PM75RL1A120	PM75RL1B120
PM150RL1A060	PM150RL1B060	PM100RL1A120	
PM200RL1A060		PM150RL1A120	
PM300RL1A060			

6pack (Inverter)

600V (AC200)		1200V (AC400V)	
Screw type	Pin type	Screw type	Pin type
PM50CL1A060	PM50CL1B060	PM25CL1A120	PM25CL1B120
PM75CL1A060	PM75CL1B060	PM50CL1A120	PM50CL1B120
PM100CL1A060	PM100CL1B060	PM75CL1A120	PM75CL1B120
PM150CL1A060	PM150CL1B060	PM100CL1A120	
PM200CL1A060		PM150CL1A120	
PM300CL1A060			

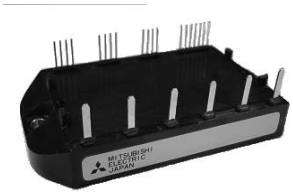
S1-series IPM

6pack (Inverter)

600V (AC200)	1200V (AC400V)
Screw type	Screw type
PM50CS1D060	PM25CS1D120
PM75CS1D060	PM50CS1D120
PM100CS1D060	PM75CS1D120
PM150CS1D060	PM100CS1D120
PM200CS1D060	

Package

IPM L1-series Mini-package



Small pin type package

IPM L1-series Small-package

Screw type package

Pin type package

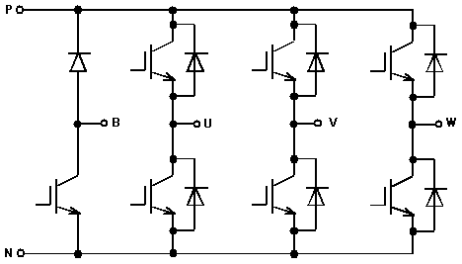
IPM L1-series Medium-package

Screw type package

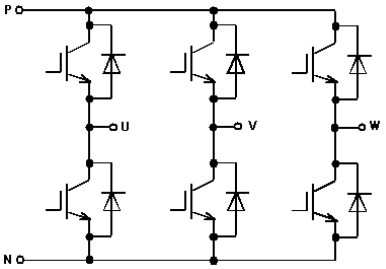
IPM S1-series package

Screw type package

2.Internal circuit



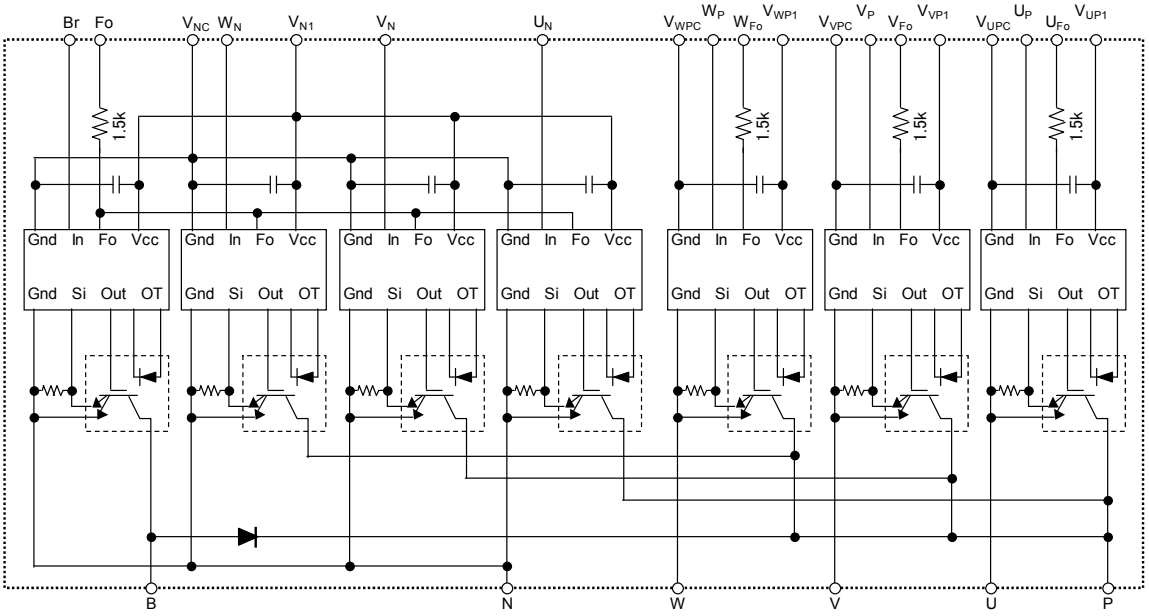
7pack (Inverter+ Brake)



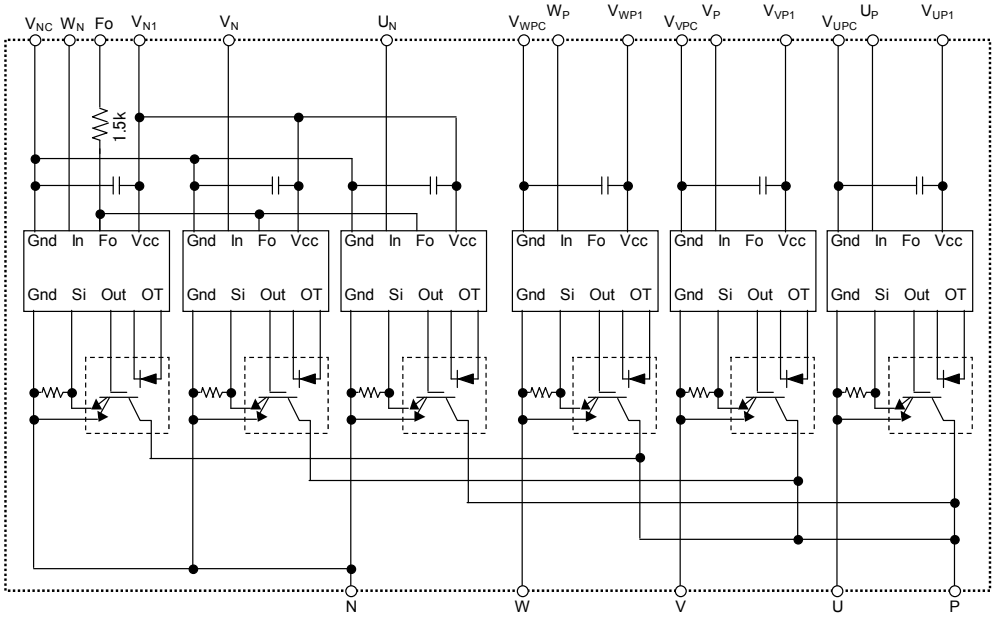
6pack (Inverter)

L1-series

Ex.) 7in1 type

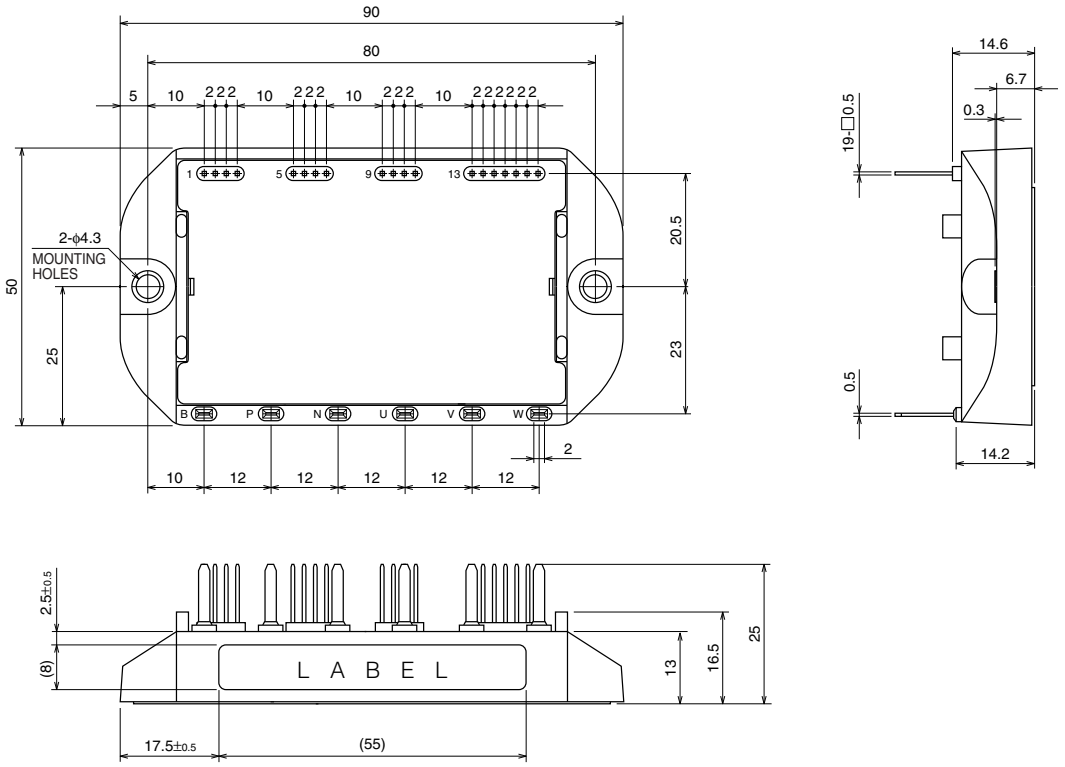


S1-series

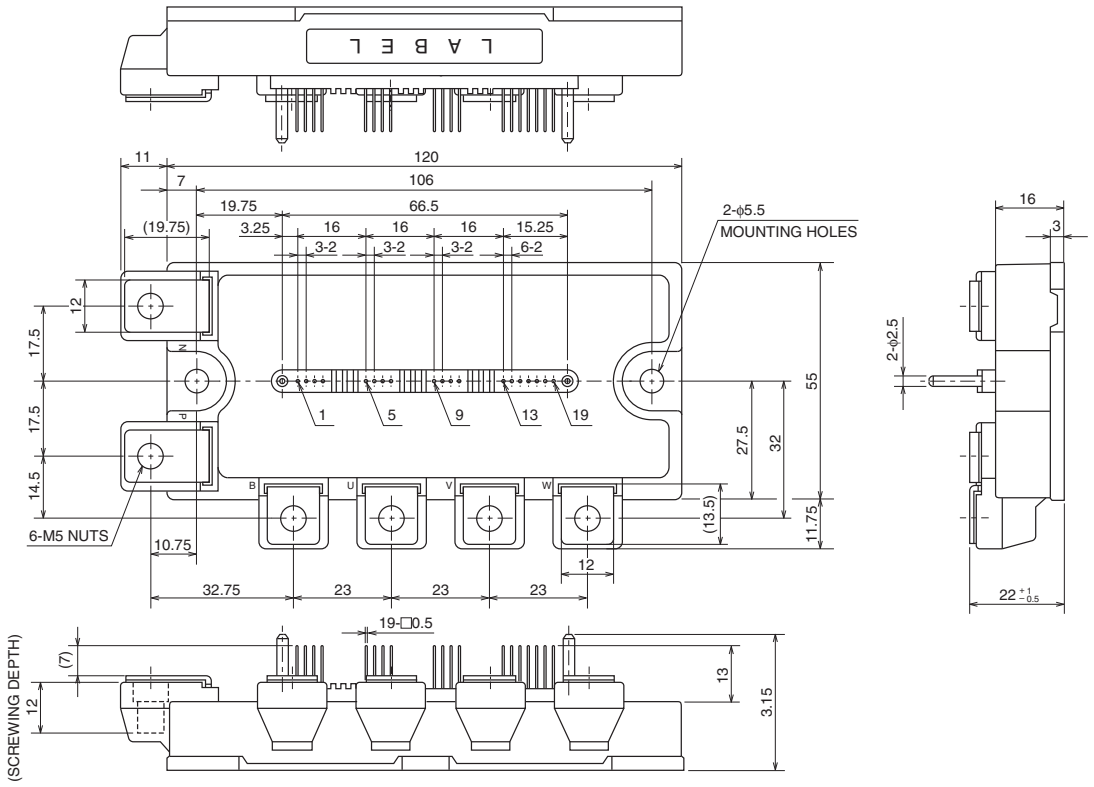


3.Package Outline

IPM L1-series Mini-package

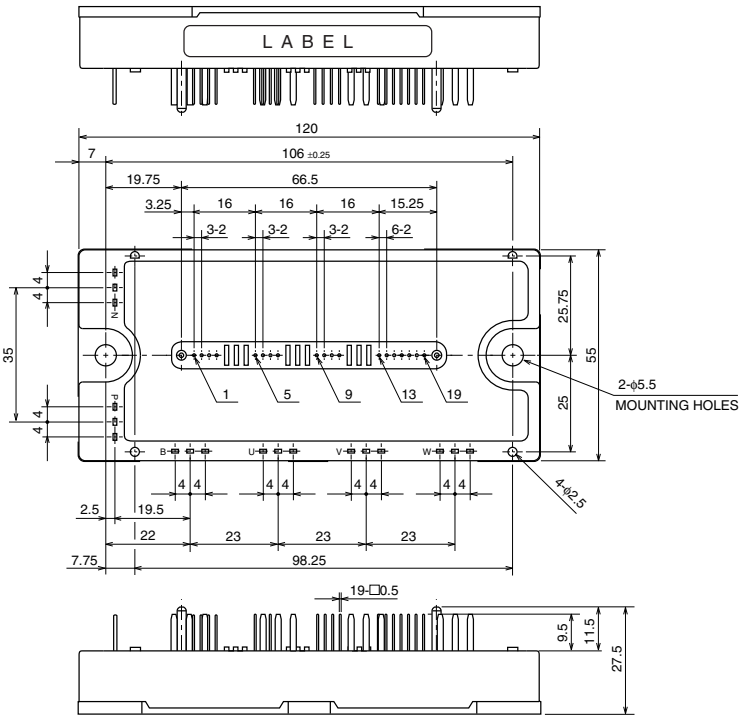


IPM L1-series Small-package (Screw type)

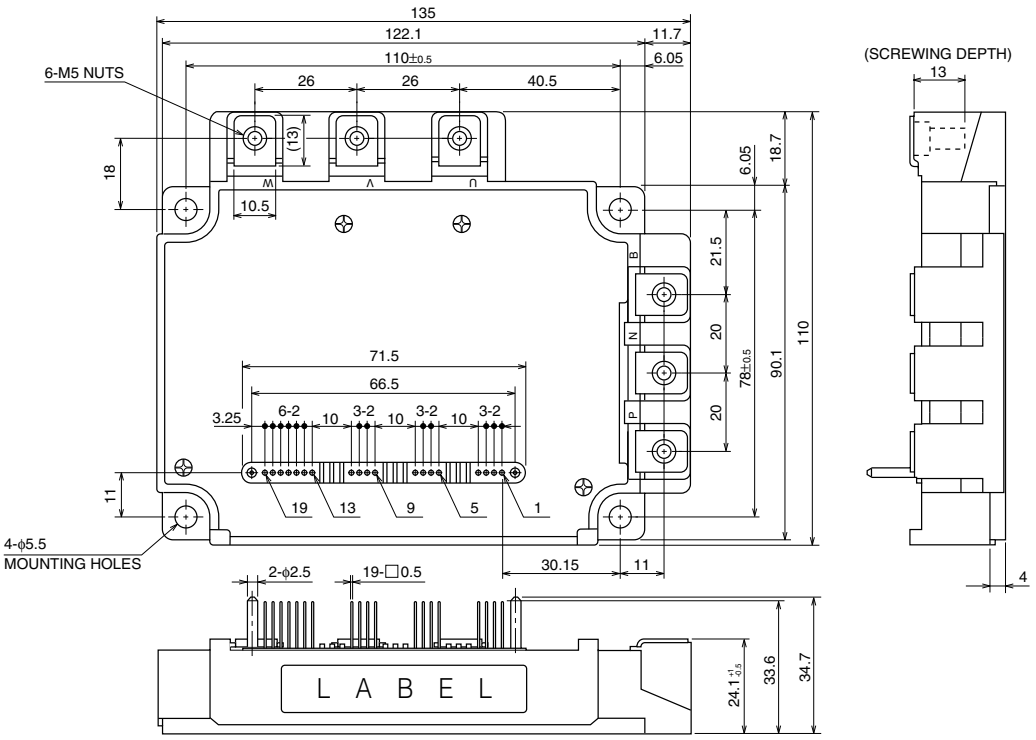


Package Outline

IPM L1-series Small-package (Pin type)

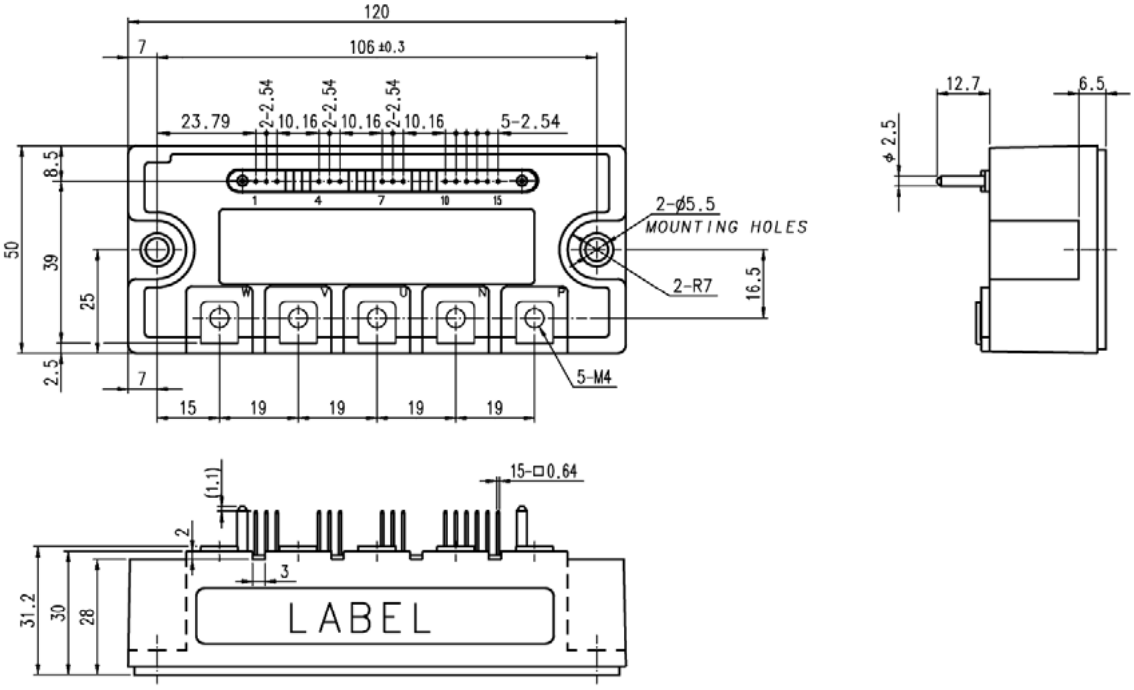


IPM L1-series Medium-package



Package Outline

IPM S1-series package



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

■AC220V Line

Motor Ratings (kW)	For Inverter Module	For Converter Diode
	L1-series	
3.7	PM50RL1A060,PM50RL1B060 PM50CL1A060,PM50CL1B060 PM50RL1C060	RM30TA-H
5.5/7.5	PM75RL1A060,PM75RL1B060 PM75CL1A060,PM75CL1B060	RM30TA-H
11.0	PM100RL1A060,PM100RL1B060 PM100CL1A060,PM100CL1B060	RM50TC-H
15.0/18.5	PM150RL1A060,PM150RL1B060 PM150CL1A060,PM150CL1B060	RM75TC-H
22.0	PM200RL1A060,PM200CL1A060	RM75TC-H
30.0	PM300RL1A060,PM300CL1A060	PM100DZ-H × 3

■AC440V Line

Motor Ratings (kW)	For Inverter Module	For Converter Diode
	L1-series	
5.5	PM25RL1A120,PM25RL1B120 PM25CL1A120,PM25CL1B120 PM25RL1C120	RM20TA-2H
7.5	PM50RL1A120,PM50RL1B120 PM50CL1A120,PM50CL1B120	RM50TC-2H
11.0/15.0	PM75RL1A120,PM75RL1B120 PM75CL1A120,PM75CL1B120	RM50TC-2H
18.5/22.0	PM100RL1A120,PM100CL1A120	RM50TC-2H
30.0	PM150RL1A120,PM150CL1A120	PM60DZ-2H × 3

Applications of IPM to Servo Motor Controls (reference)

■AC220V Line

Motor Ratings (kW)	For Inverter Module	For Converter Diode
	S1-series	
~1.5	PM50CS1D060	RM30TA-H
~2.0	PM75CS1D060	RM30TA-H
~3.5	PM100CS1D060	RM50TC-H
~6.0	PM150CS1D060	RM75TC-H
~7.5	PM200CS1D060	RM75TC-H

■AC440V Line

Motor Ratings (kW)	For Inverter Module	For Converter Diode
	S1-series	
~1.5	PM25CS1D120	RM20TA-2H
~3.0	PM50CS1D120	RM50TC-2H
~5.0	PM75CS1D120	RM50TC-2H
~6.0	PM100CS1D120	RM50TC-2H

The above-mentioned tables are examples of the reference.
It is necessary to select the power-module (IPM) from the power-loss and the heat calculation result in the voltage, the current, and use conditions.

5. Term Explanation

General 1

Symbol		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_{CP}	Peak Collector Current Repetitive	Peak collector current, Tj≤150°C
P_C	Power Dissipation	Maximum power dissipation, per device, T_C=25°C
T_j	Junction Temperature	Allowable range of IGBT junction 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_{iso}	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

※I_E and I_F are using by the difference of the connection and so on like the following figure.

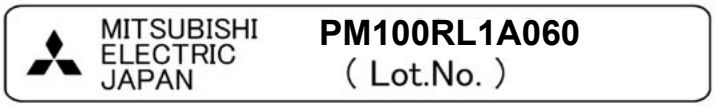
Electrical Characteristics

Symbol	Parameter	Definition
I_{CES}	Collector-Emitter Leakage Current	I_C at V_{CE} = V_{CES}, V_{CIN} = 15V
$V_{CE(sat)}$	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 Crossover Time	Time from V_{CE}=10% to I_C=10% of final value
E_{on}	Turn-on Switching loss	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 loss	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
$R_{th(c-f)}$	Thermal Resistance, Case to Fin	I_C conducting to establish thermal equilibrium lubricated

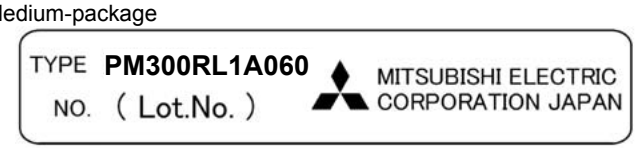
6. Numbering System

Label)

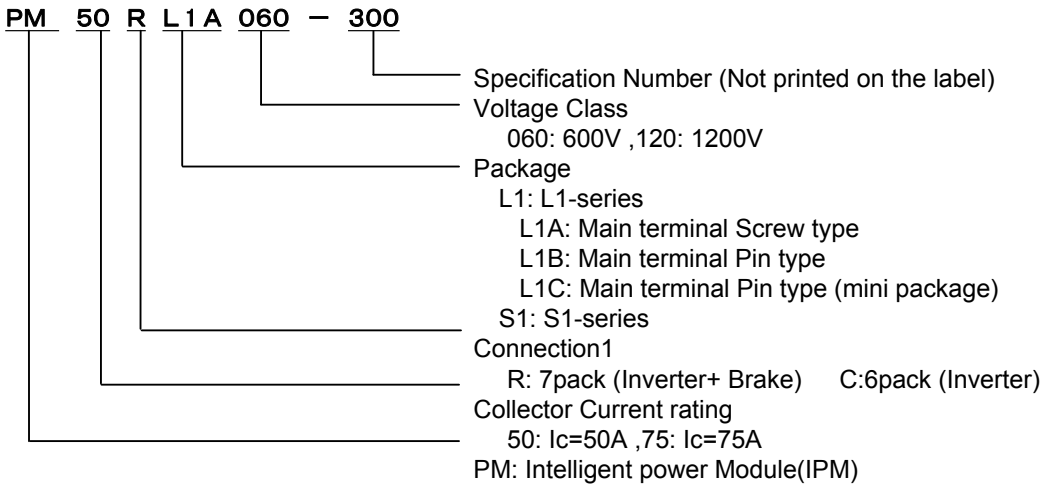
L1-series Mini-package ,L1-series Small-package, S1-series



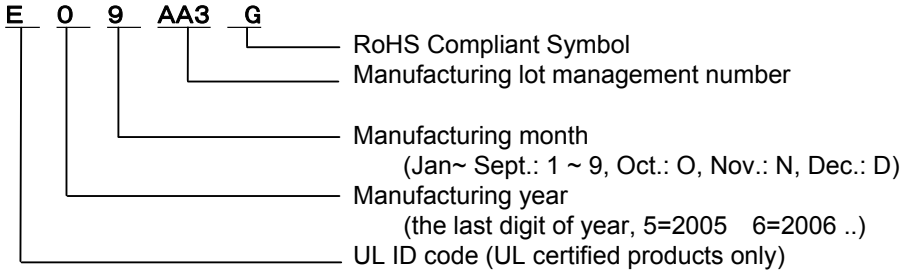
L1-series Medium-package



Type Name)

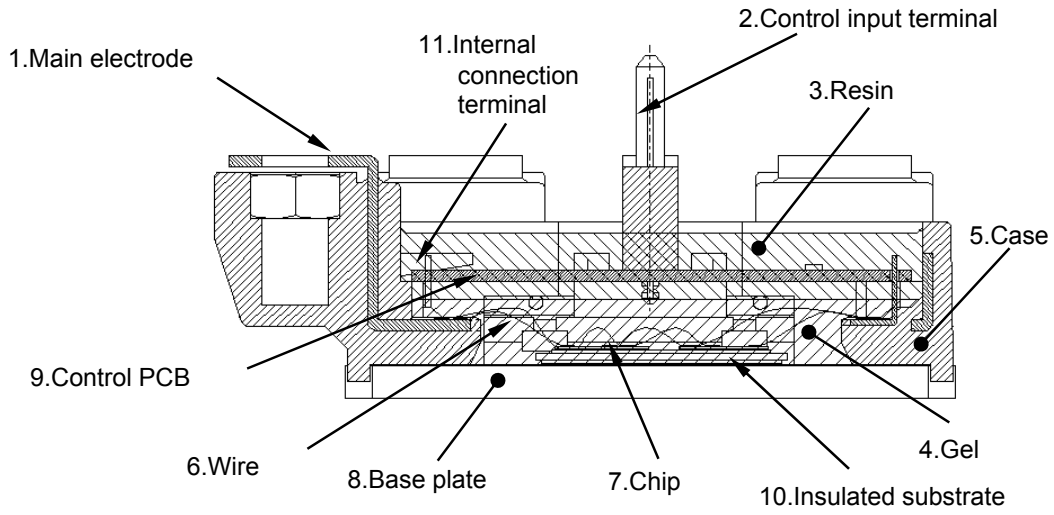


Lot Number)



7. Structure

ex.) L1-series Small package Screw type

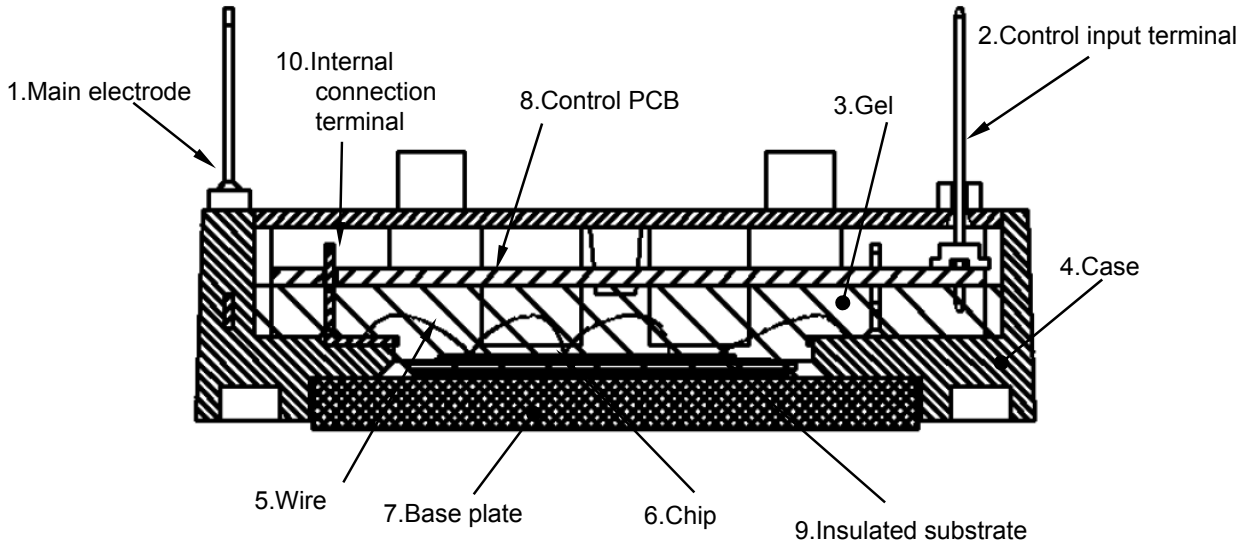


	Part	Quality of the material	UL Flame class
1	Main electrode	Copper plated with nickel	
2	Control input terminal	Brass plated with gold	
		PBT resin	UL 94-V0
3	Resin	Epoxy	UL 94-V0
4	Gel	Silicone	
5	Case	PPS resin	UL 94-V0
6	Wire	Aluminum	
7	Chip	Silicon	
8	Base plate	Copper	
9	Control PCB	Glass epoxy	UL 94-V0
10	Insulated substrate	Ceramic	
11	Internal connection terminal	Copper plated with nickel	

Note of Insulated substrate

IPM has UL(Underwriters Laboratories Inc) Yellow Card #80276 (file. #80271).

ex.) L1-series Mini package Screw type

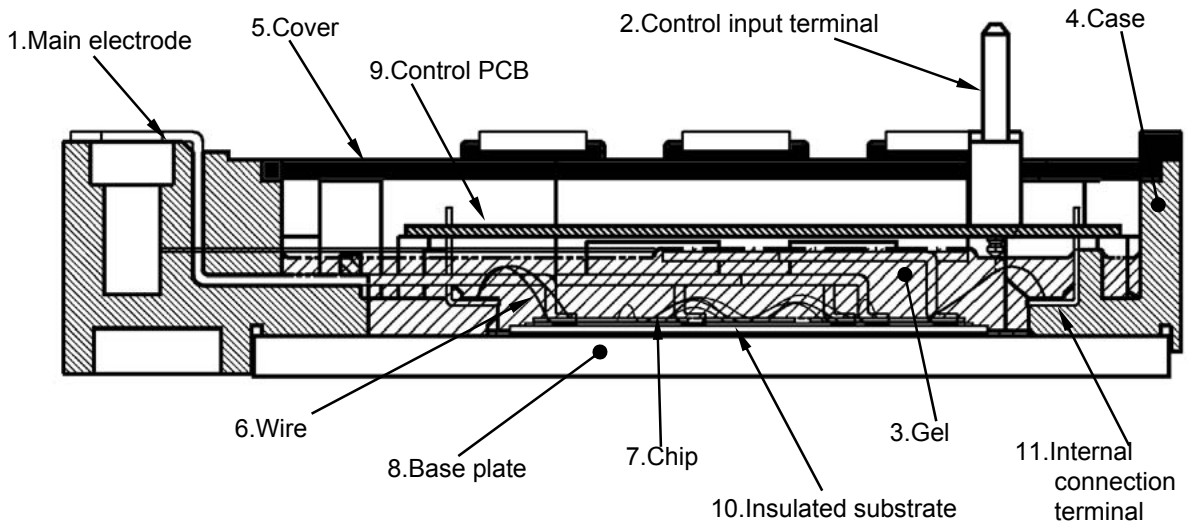


	Part	Quality of the material	UL Flame class
1	Main electrode	Copper plated with nickel	
2	Control input terminal	Brass plated with tin	
3	Gel	Silicone	
4	Case	PPS resin	UL 94-V0
5	Wire	Aluminum	
6	Chip	Silicon	
7	Base plate	Copper	
8	Control PCB	Glass epoxy	UL 94-V0
9	Insulated substrate	Ceramic	
10	Internal connection terminal	Copper plated with nickel	

Note of Insulated substrate

IPM has UL(Underwriters Laboratories Inc) Yellow Card #80276 (file. #80271).

ex.) L1-series Medium package

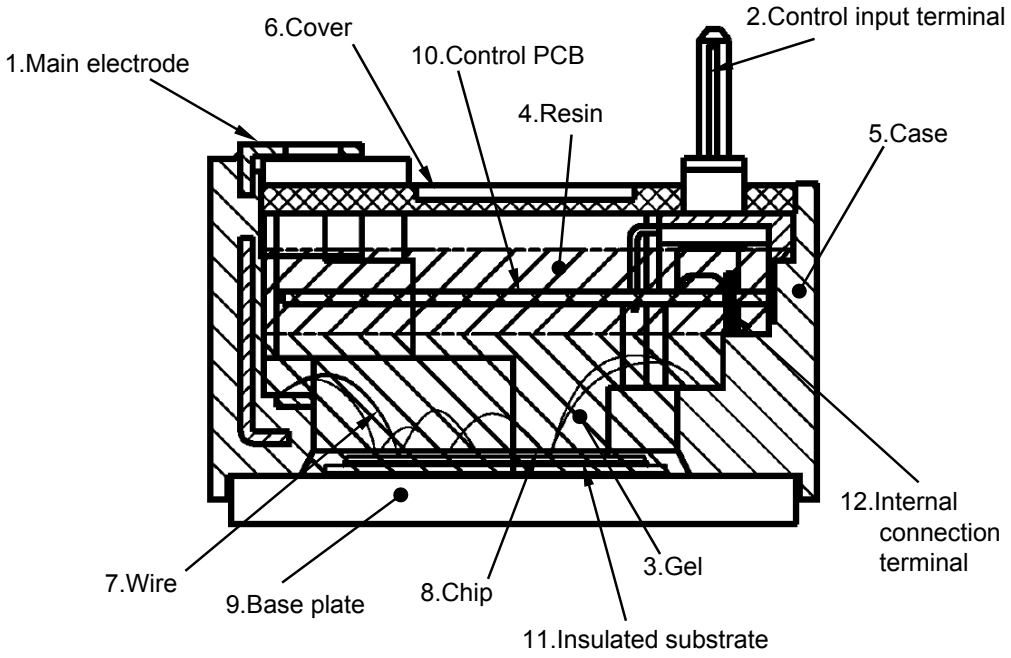


	Part	Quality of the material	UL Flame class
1	Main electrode	Copper plated with nickel	
2	Control input terminal	Brass plated with gold	
		PBT resin	UL 94-V0
3	Gel	Silicone	
4	Case	PPS resin	UL 94-V0
5	Cover	PPS resin	UL 94-V0
6	Wire	Aluminum	
7	Chip	Silicon	
8	Base plate	Copper	
9	Control PCB	Glass epoxy	UL 94-V0
10	Insulated substrate	Ceramic	
11	Internal connection terminal	Copper plated with nickel	

Note of Insulated substrate

IPM has UL(Underwriters Laboratories Inc) Yellow Card #80276 (file. #80271).

ex.) S1-series package



	Part	Quality of the material	UL Flame class
1	Main electrode	Copper plated with nickel	
2	Control input terminal	Brass plated with gold	
		PBT resin	UL 94-V0
3	Gel	Silicone	
4	Resin	Epoxy	UL 94-V0
5	Case	PPS resin	UL 94-V0
6	Cover	PPS resin	UL 94-V0
7	Wire	Aluminum	
8	Chip	Silicon	
9	Base plate	Copper	
10	Control PCB	Glass epoxy	UL 94-V0
11	Insulated substrate	Ceramic	
12	Internal connection terminal	Copper plated with nickel	

Note of Insulated substrate
IPM has UL(Underwriters Laboratories Inc) Yellow Card #80276 (file. #80271).

8. Correct and 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 water, 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.
Anti-electrostatic Measures	(1) Precautions against the device rupture caused by static electricity Static electricity of human bodies and cartons and/or excessive voltage applied across the gate to emitter 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. * Gate to emitter should be always shorted with a carbon cloth or the like until right before a module is used. Never touch the gate terminals with bare hands.
Anti-electrostatic Measures	* Always ground the equipment and your body during installation (after removing a carbon cloth or the like. It is advisable to cover the workstation and it's surrounding floor with conductive mats and ground them. * It should be noted that devices may get damaged by the static electricity charged to a printed circuit board if the gate to emitter of the circuit board is open. * Use soldering irons with grounded tips. (2) Precautions when the gate to emitter is open * Voltage should not be applied across the collector to emitter when the gate to emitter is open. * The gate to emitter should be shorted before removing a device from a unit.

⚠ 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, since stress is applied on a ceramic plate and silicon chips inside the module. Shown in following figure is the recommended torquing order for mounting screws.

a) Two point mounting type b) four point mounting type c) eight point mounting type

Temporary tightening :①→②	①→②→③→④	①→②→③→④→⑤→⑥→⑦→⑧
Final tightening :②→①	④→③→②→①	①→②→③→④→⑤→⑥→⑦→⑧

The recommended torquing order for mounting screws

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

Also, care must be taken to achieve maximum contact (i.e. minimum contact thermal resistance) for the best heat dissipation.)

The flatness of a heat sink where a module is mounted (ref. following figure) should be as follows. Also, the surface finish should be less than Rz12s.

Copper base plate module:−100μm~+100μm

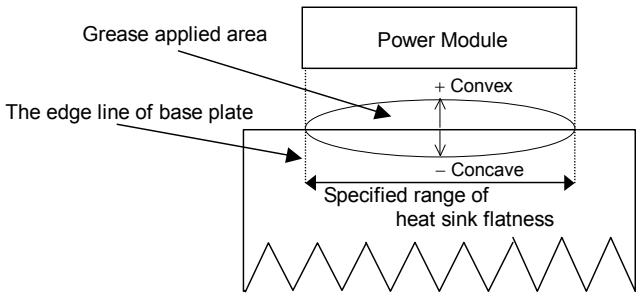
Thermal compound with good thermal conductivity should be applied evenly about Aluminum base plate modules:−100μm~+200μm on the contact surface of a module and a heat sink.

Heat sink flatness: Less than ± 20 micrometers on a length of 100mm
/Less than 10 micrometers of roughness

Thermal grease thickness: +50~+100μm

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

9.Reliability

Please refer to the URL of our web site. “http://www.mitsubishichips.com/Global/index.html”

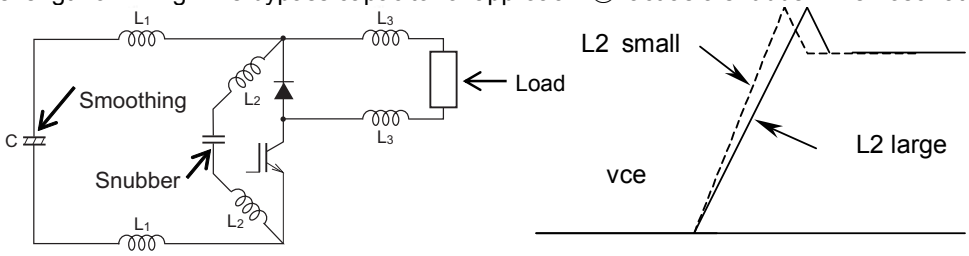
10. Installation of power Module

10-1. Installing Capacitor

During switching, voltage is induced in power circuit stray inductance by the high di/dt of the main current. This voltage can appear on the IPM and cause damage. In order to avoid this problem, guidelines that should be followed in designing the circuit layout are:

① Located the smoothing capacitor as close as possible to the IPM
② Use ceramic capacitor near the IPM to bypass high frequency current
③ Adopt low impedance electrolytic capacitor as smoothing capacitor
④ Use snubber circuit to absorb surge voltage
⑤ Decrease switching speed in order to lower di/dt.

② and ⑤ are the most effective to reduce surge voltage. The stray inductance of snubber circuit generally is not considered to avoid complicating the circuit. In addition, combination of ②, ④, ⑤ is needed since there is a limit on the length of wiring. The bypass capacitor of approach ② act as a snubber when oscillation is occurring.



L1 : Stray inductance between the electrolytic capacitor and the IPM.
L2 : Stray inductance between the filter capacitor and the driver.
L3 : Stray inductance between the load and the power circuit's output stage

10-2. Installation Hints

When mounting IPM on a heat-sink, uneven mounting can cause the modules ceramic isolation to crack. To achieve the best thermal radiation effect, the bigger the contact area is, the smaller the thermal resistance is. Heat-sink should have a surface finish in range of Rz6 ~ Rz12, curvature within 100μm.

Uniform coating of thermal grease between the module and heat-sink can prevent corrosion of contact parts. Select a compound, which has stable characteristics over the whole operating temperature range and does not change its properties over the life of the equipment.

Use a uniform coating of thermal interface compound. The thickness of thermal grease should be ranked in 100~200μm according to the surface finish.

Mounting screws should be tightened by using a torque wrench to the prescribed torque in progressive stages in a cross pattern. As mentioned before, over torque terminal or mounting screws may result in damage of IPM.

When an electric driver is used, thermal grease with low viscosity is recommended and extra grease must be extruded before final tightening screws.

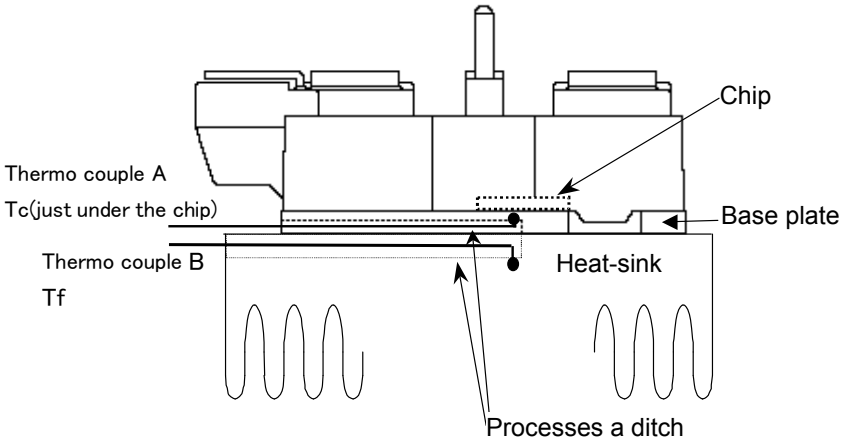
* For the recommended torque order for mounting screws referring to "Installation Method" in the section of
"Correct and Safety Use of Power Module"

Note) Maximum torque specifications are provided in device data sheets. The type and quantity of thermal compounds having an effect on the thermal resistance are determined by consideration of both thermal grease and heat-sink. Typical value given in datasheet is measured by using thermal grease produced by Shin-Etsu Chemical Co.,Ltd.
(G-746, which has not issued in Shin-Etsu's publications, is almost the same as G-747.)

10-3. Thermal Impedance Considerations & Chip Layout

The junction to case thermal resistance $R_{th(j-c)}$ and the case to heat-sink thermal resistance $R_{th(c-f)}$ are given in datasheet.

The case temperature has been measured at the just under the chip. The chip location is given with a data sheet.



·Note

*The thermal impedance depends on the material, area and thickness of heat-sink. The smaller the area and the thinner the heat-sink is, the lower the impedance is for the same material.

*The type and quantity of thermal compounds can affect the thermal resistance.

Thermal resistance of IPM L1-series

Thermal resistance 600V type

Type Name	Inverter part Just under the chip		Brake part Just under the chip		contact thermal resistance
	IGBT-chip Rth(j-c)Q	FWDi-chip Rth(j-c)	IGBT-chip Rth(j-c)Q	FWDi(P)-chip Rth(j-c)	Rth(c-f)
PM50RL1C060	0.74	1.28	0.74	1.28	0.085
PM50RL1A060, PM50RL1B060	0.44	0.75	0.44	0.75	0.038
PM50CL1A060, PM50CL1B060	0.44	0.75	-	-	0.038
PM75RL1A060, PM75RL1B060	0.37	0.63	0.44	0.75	0.038
PM75CL1A060, PM75CL1B060	0.37	0.63	-	-	0.038
PM100RL1A060, PM100RL1B060	0.32	0.52	0.44	0.75	0.038
PM100CL1A060, PM100CL1B060	0.32	0.52	-	-	0.038
PM150RL1A060, PM150RL1B060	0.25	0.41	0.38	0.64	0.038
PM150CL1A060, PM150CL1B060	0.25	0.41	-	-	0.038
PM200RL1A060	0.20	0.30	0.32	0.53	0.023
PM200CL1A060	0.20	0.30	-	-	0.023
PM300RL1A060	0.15	0.23	0.24	0.39	0.023
PM300CL1A060	0.15	0.23	-	-	0.023

Thermal resistance 1200V type

Type Name	Inverter part Just under the chip		Brake part Just under the chip		contact thermal resistance
	IGBT-chip Rth(j-c)Q	FWDi-chip Rth(j-c)	IGBT-chip Rth(j-c)Q	FWDi(P)-chip Rth(j-c)	Rth(c-f)
PM25RL1C120	0.70	1.18	0.70	1.18	0.085
PM25RL1A120,PM25RL1B120	0.97	1.60	0.97	1.60	0.038
PM25CL1A120,PM25CL1B120	0.97	1.60	-	-	0.038
PM50RL1A120,PM50RL1B120	0.27	0.47	0.39	0.67	0.038
PM50CL1A120,PM50CL1B120	0.27	0.47	-	-	0.038
PM75RL1A120,PM75RL1B120	0.21	0.36	0.27	0.47	0.038
PM75CL1A120,PM75CL1B120	0.21	0.36	-	-	0.038
PM100RL1A120	0.19	0.31	0.28	0.48	0.023
PM100CL1A120	0.19	0.31	-	-	0.023
PM150RL1A120	0.15	0.23	0.21	0.36	0.023
PM150CL1A120	0.15	0.23	-	-	0.023

Thermal resistance of IPM S1-series

Thermal resistance 600V type

Type Name	Inverter part Just under the chip		contact thermal resistance
	IGBT-chip Rth(j-c)Q	FWDi-chip Rth(j-c)	Rth(c-f)
PM50CS1D060	0.40	0.68	0.046
PM75CS1D060	0.33	0.55	0.046
PM100CS1D060	0.28	0.46	0.046
PM150CS1D060	0.21	0.35	0.046
PM200CS1D060	0.18	0.27	0.046

Thermal resistance 1200V type

Type Name	Inverter part Just under the chip		contact thermal resistance
	IGBT-chip Rth(j-c)Q	FWDi-chip Rth(j-c)	Rth(c-f)
PM25CS1D120	0.37	0.59	0.046
PM50CS1D120	0.25	0.41	0.046
PM75CS1D120	0.20	0.32	0.046
PM100CS1D120	0.18	0.27	0.046

10-4. 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

② Relationship between the coating amount and thickness is,

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

The recommended thickness of grease is 100μm~200μm.
The amount of grease can be obtained as the following example.

For example : For case with size of 110×89(PM100CSD060), the amount of Shin-Etsu Chemical Co.,Ltd. grease G-746 can be calculated through the equation below.

$$100 \sim 200\mu\text{m} = \frac{\text{amount of grease}\,[\text{g}]}{97.9[\text{cm}^2] \times 2.66[\text{g/cm}^3]}$$

$\therefore$The amount needed is$\fallingdotseq$2.6~5.2 [g]

③ Measure the mass of module

④ Measure the grease with the same amount as calculated

⑤ Coating the module base uniformly by using scraper or roller

⑥ Mask print of grease.

Finally it is fulfilled to uniformly cover thermal grease on the module base with specified thickness.

Thermal Compounds

Manufacturer	Type	Note
Shin-Etsu Chemical Co., Ltd. Momentive Performance Materials	KS-613, G-747, else YG6260, YG6260V	
ALCAN	UNIVERSAL JOINTING-COMPOUND	For non-insulation type

For more information, please refer to manufacturers.

ALCAN UNIVERSAL JOINTING-COMPOUND is grease for the aluminum conductor connection.
The purpose of grease is electricity and a contact resistance decline by the contact-ability improvement and the corrosion control of the aluminum surface.
It seems that there is long-range use experience but because we are not the one of the purpose to improve a heat conduction at the contacted part, the contact thermal resistance reductional effect cannot look forward to it too much. When employing these, the more enough radiation design becomes necessary.

10-5. Connecting the Interface circuit

The input pins of Mitsubishi Intelligent Power Modules are design to be connected directly to a printed circuit board. Noise pick up can be minimized by building the interface circuit on the PCB near the input pins of the module. L1B,L1C type modules have tin plated control and power pins that are designed to be soldered directly to the PCB. L1A, S1D type modules have gold plated pins that are design to be connected to the PCB using an inverse mounted header receptacle. It is the special connector of IPM which secured an electrical clearance among the terminals (U-V, V-W, W-U of P-side and N). The terminal with gold plate is recommended from the viewpoint of contact reliability.

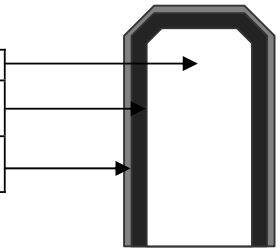
IPM type	Connection method and type name of connector
PM50RL1C060 PM25RL1C120 PM50RL1B060, PM50CL1B060 PM75RL1B060, PM75CL1B060 PM100RL1B060, PM100CL1B060 PM150RL1B060, PM150CL1B060 PM25RL1B120, PM25CL1B120 PM50RL1B120, PM50CL1B120 PM75RL1B120, PM75CL1B120	Main terminal Connect by solder. Control terminal Connect by solder.
PM50RL1A060, PM50CL1A060 PM75RL1A060, PM75CL1A060 PM100RL1A060, PM100CL1A060 PM150RL1A060, PM150CL1A060 PM200RL1A060, PM200CL1A060 PM300RL1A060, PM300CL1A060 PM25RL1A120, PM25CL1A120 PM50RL1A120, PM50CL1A120 PM75RL1A120, PM75CL1A120 PM100RL1A120, PM100CL1A120 PM150RL1A120, PM150CL1A120	Main terminal Connect by screw (screw:M5). Control terminal Connect by connector. **DF10-31S-2DSA(68), or DF10-31S-2DSA(62)** (HIROSE ELECTRIC CO., LTD)
PM50CS1D060, PM75CS1D060 PM100CS1D060, PM150CS1D060 PM200CS1D060 PM25CS1D120, PM50CS1D120 PM75CS1D120, PM100CS1D120	Main terminal Connect by screw (screw:M4). Control terminal Connect by connector. **MDF7-25S-2.54DSA(31), or MDF7-25S-2.54DSA(32)** (HIROSE ELECTRIC CO., LTD)

10-6. Terminal of IPM

(1) The material of control terminal of IPM (L1-series RL1A, CL1A type /S1-series)

As a reference of the connector selection, the material and the metal finishing of the control terminal on the side of IPM are shown below.

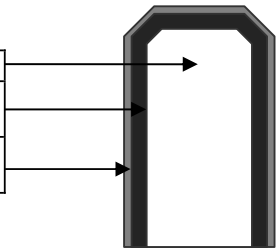
Main material		Brass
The specification of the plating	Substrate	Nickel (Ni) thickness= 1 ~ 5 um
	Surface	Gold (Au) thickness= 0.05 ~ 0.2 um



(2) The material of control terminal of IPM (L1-series RL1B, CL1B type)

As a reference of the connector selection, the material and the metal finishing of the control terminal on the side of IPM are shown below.

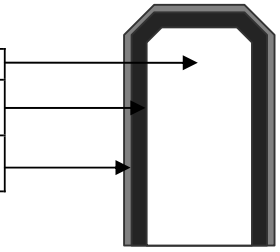
Main material		Brass
The specification of the plating	Substrate	Nickel (Ni) thickness= 1 ~ 6 um
	Surface	Tin (Sn) thickness= 4 ~ 10 um



(3) The material of control terminal of IPM (L1-series RL1C type)

As a reference of the connector selection, the material and the metal finishing of the control terminal on the side of IPM are shown below.

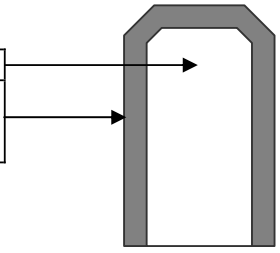
Main material		Brass
The specification of the plating	Substrate	Nickel (Ni) thickness= 0.5 ~ 1 um
	Surface	Tin (Sn) thickness= 2 ~ 6 um



(4) The material of main terminal of IPM

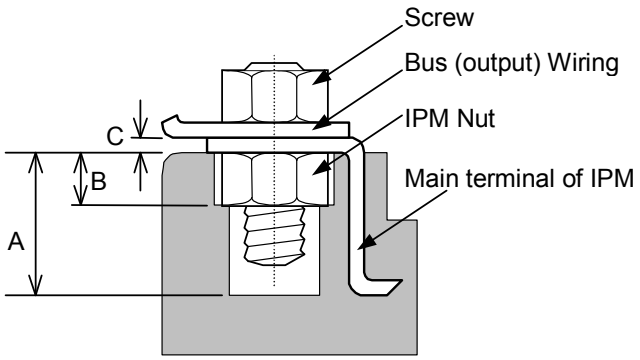
As a reference of the connector selection, the material and the metal finishing of the main terminal on the side of IPM are shown below.

Main material		Copper
The specification of the plating	Surface	Nickel (Ni) thickness= 2 ~ 6 um



(5) The main terminal of IPM

The structure of main terminal of IPM are shown bellow.



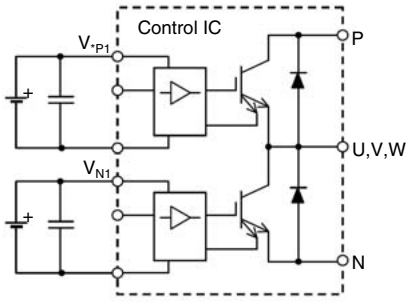
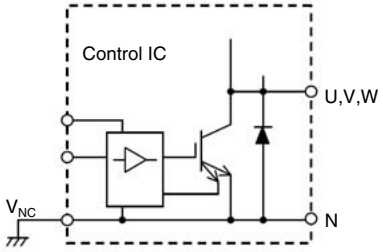
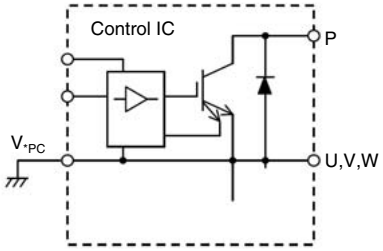
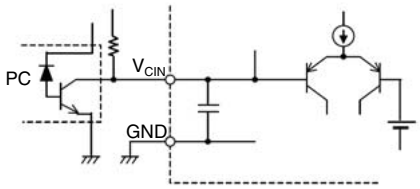
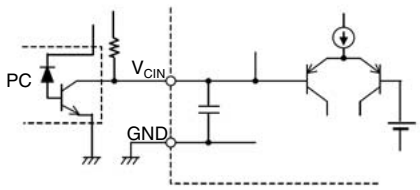
Package	Screw	Deepness of Screw Hole Mark A (mm)	Thickness of IPM Nut Mark B (mm)	Thickness of Main Terminal Mark C (mm)
L1-series RL1A/CL1A	M5	Typ. 9.5/ min. 9.0	Typ. 4.0	Typ. 0.8
S1-series	M4	Typ. 6.5/ min. 6.0	Typ. 3.3	Typ. 0.8

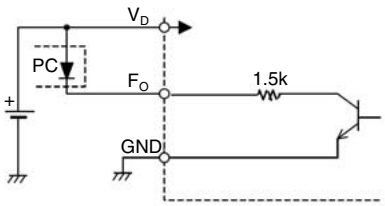
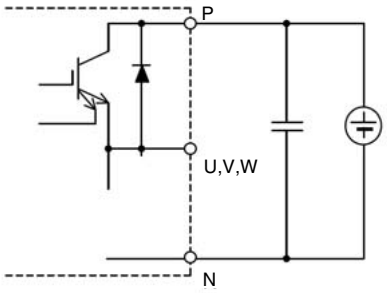
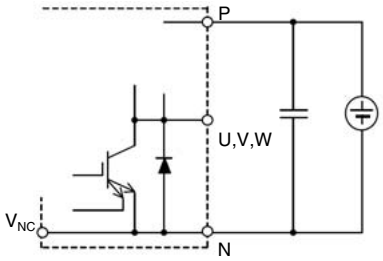
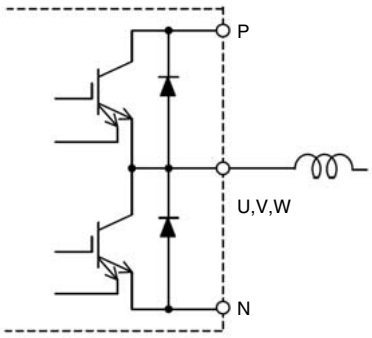
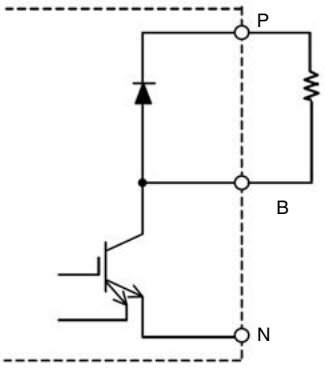
(6) The guide pin of IPM

The guide pin on both sides of the control terminal of IPM is metal. The guide pin is molded by plastic, and isolated.

11. Using IPM

11-1. Instruction of the symbol of a terminal of IPM

No	Name	Symbol	Equivalent Circuit	Operation (description)
1	Power -supply	V_D V_{UP1} V_{VP1} V_{WP1}		Power supply terminals for control IC and driving IGBT. Supply power commonly to lower arms and individual, insulated power to upper arms. For 6in1 and 7in1 types, 4 independent power supplies are required; three to upper arms and one to lower arm. UV lock-out functions if power is 12.5VDC or lower. Control signals are not effective for operation under this condition. Fo signal is output. If power is 16.5VDC or higher, operation is not guaranteed under short circuit condition. This is due to IGBT gate characteristics. Typical value is 15VDC. In order to prevent malfunction caused by noise and ripples in supply voltage, connect a smoothing capacitor of favorable frequency characteristics very close to IC terminals.
2	Ground	V_{NC}		Ground for reference power supply for lower arms. This ground is common to each of three phase for 6- or 7-element types. This is also the ground of control power supply. Bus line current should not be allowed to flow through this terminal to avoid noise influences. PCB pattern should not be such that connects this terminal and N. This terminal is internally connected to inverter ground N. Difference in electric potential between N and VNC may occur in practical operation.
		V_{UPC} V_{VPC} V_{WPC}		Grounds for reference power supply for upper arm of each phase. Lower power supply impedance as much as possible for greater resistance to noise. Insulate each phase of U, V and W.
3	Control -signal	U_P V_P W_P U_N V_N W_N		Input terminals for controlling IPM switching operation. Operates by voltage input signals. Internally connected to comparator. In usual applications, external pull-up resistor is connected to control power supply, and external opto-coupler for insulation purpose is also connected. As these terminals are susceptive of noise, design a shortest route in pattern layout and also take care for wiring. Connect a capacitor having good frequency characteristics between power supply and GND.
4	Brake Control -signal	Br		This terminal is used with R_{XX} series. The purpose of this terminal is to prevent increase in P-N voltage, which is caused by regenerative current produced when AC motor decelerates. In usual applications, external pull-up resistor is connected to control power supply, and external opto-coupler for insulation purpose is also connected. This terminal has the same structure as control signal terminals, accordingly are susceptive of noise. Take similar measures.

5	Fault -output	F_O		This is the output indicating faulty state of IPM. Faulty modes are classified into overheat, load (arm) short circuit, control power supply under voltage protection. This output does not make distinction of these modes, however. The terminal is an open collector with resistor connected in series. It is possible to directly insert a opto-coupler (or LED) between this terminal and V_D.
6	Inverter Power -supply	P		Power supply terminal to inverter. In usual applications, connect this terminal to positive (+) line after rectifying AC line. Internally connected to collector of upper arm IGBT. In order to suppress surge voltage caused by inductance component of PCB pattern, connect a smoothing capacitor very close to P and N terminals. It is also effective to add a film capacitor of good frequency characteristics.
7	Inverter -ground	N		Power supply ground of inverter. In usual applications, connect this terminal to ground (-) line after rectifying AC line. Make connection so that bus line current flows through this terminal. Internally connected to emitter of lower arm IGBT. This terminal is also connected to reference control ground V_{NC}. Difference in electric potential between VNC and N may occur in practical operation due to IPM's internal parasitic inductance.
8	Output	U V W		Inverter output terminal. A load such as AC motor is connected in usual applications. Take care for generation of surge voltage. Internally connected to mid point of IGBT modules (IPM) of half-bridge configuration.
9	Brake -output	B		This terminal is used with R_{XX} series. The purpose of this terminal is to prevent increase in P-N voltage, which is caused by regenerative current produced when AC motor decelerates. In usual applications, power dissipating resistor (brake resistor) is connected between this terminal and upper arm. Since this terminal is designed taking into account regenerative current produced when AC motor is decelerates, the current rating of this terminal is about 50% of that of IGBT chip used for U, V, and W. This terminal cannot endure use involving special control that allows a large current to flow.