DIP Type Module
Application note

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2019/March Publishment
Rev.A

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1. Features and Application

1-1. Product summary

The DF60NB160 is Diode module of 3 phase rectifier bridge (Fig.1-1, 1-2).

This is new package product of PCB mount type that able to use at 3 phase input 200V and 400V line (Hereinafter called “Dip type module”).

Fig.1-1 DF60NB160 type showing side

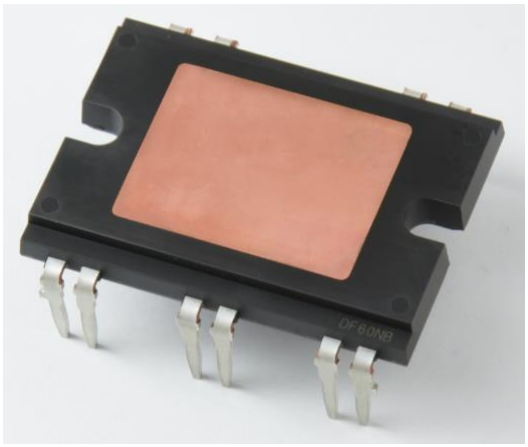


Fig.1-2 DF60NB160 heat dissipation side

1-2. Small package and low profile

Device mount area becomes about 55% compared with existing model DF60LB160 (1600V/60A).

And module height becomes 8.6mm (From PCB side) compared with 25mm of DF60LB160 (Including barrier height). So it can reduce the system size by using Dip type module.

Fig.2 DF60LB160 (Existing model）

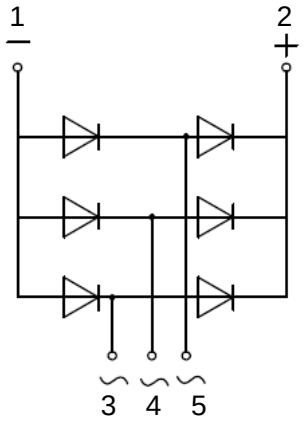


Fig.3-1 DF60NB160 internal connection

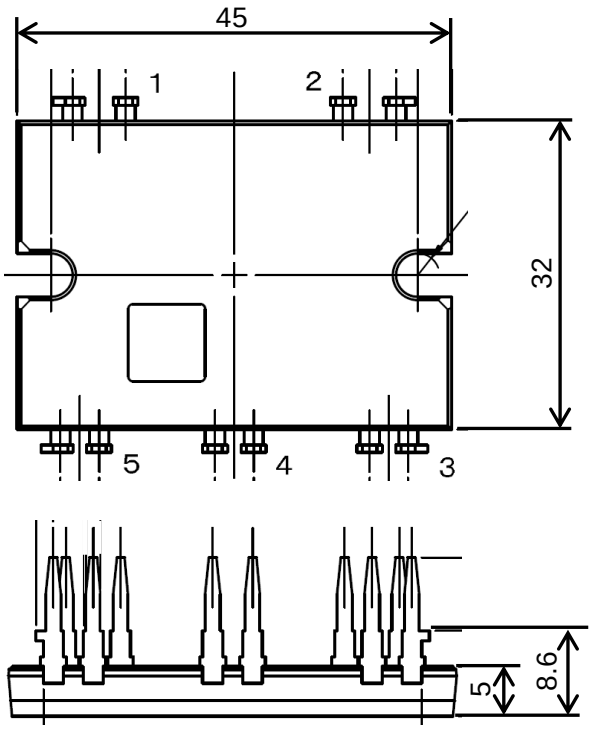


Fig.3-2 DF60NB160 Outline

1-3. High reliability

Our existing almost models are using the clip bonding, not bonding wire (Fig.4-1, 4-2).

DIP type module is also using the clip bonding.

The feature of clip bonding is high reliability, high heat dissipation, low resistance and high bond strength by soldering connection.

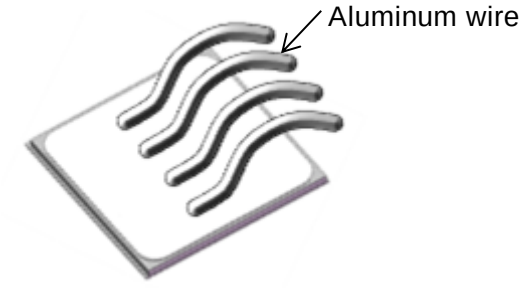


Fig.4-1 Wire bonding image

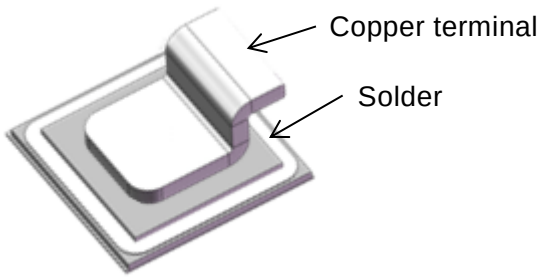


Fig.4-2 Clip bonding image

1-4. Application

DIP type module is designed for using by combining with general IPM.
Traditional inverter circuit divides to converter part and inverter part. Converter part is making smoothing power from AC input and inverter part is making the AC from smoothing power.
Currently, the part called IPM which is frequently used in the market is used for this inverter part, and the product of the converter part which can be used in combination with them becomes the DF-NB series. We are planning to releases over 75A rated current products in the future.

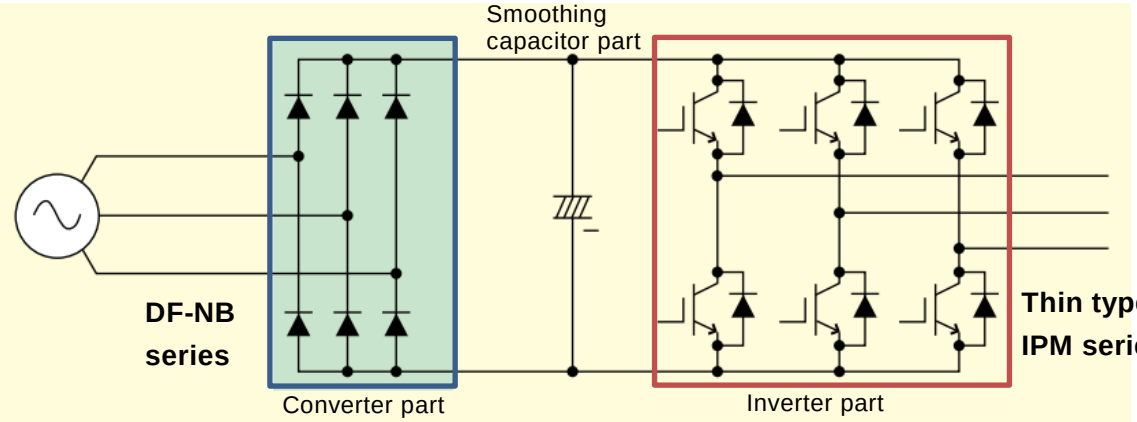


Fig.5 Traditional inverter circuit

DF-NB series are designed for using by combining with thin type IPM.
Therefore, when it mounted to the heatsink, the height from the PCB surface to heatsink mounting surface is designed to become same so that same heatsink as IPM can be used (Fig.7)
Thereby customer is able to use same PCB and heatsink to DF-NB series and IPM.
But this model is designed for using by combining with thin type IPM. So, if customer uses devices of different height IPM, customer will not be able to use same PCB and heatsink. So customer needs the following ingenuity.
・Divides the PCB to converter side and inverter side
・Divides the heatsink, or modify heatsink to steps

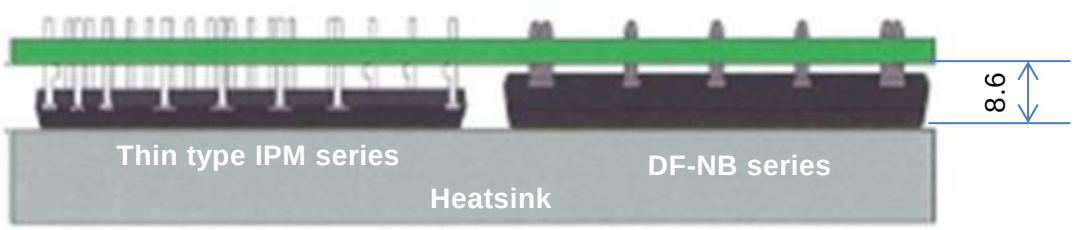


Fig.6 Mounting image with Thin type IPM

2. Electrical characteristics

2-1. Maximum Ratings

Here is explanation of DF60NB160's maximum ratings about DF-NB series specifications.

Item	Symbol	Unit	Ratings	Conditions
Repetitive Peak Reverse Voltage	V_{RRM}	V	1600	
Non-Repetitive Peak Reverse Voltage	V_{RSM}	V	1700	
DC Output Current	I_D	A	60	3 phase Full wave rectifier circuit Tc=110℃
Surge Forward Current	I_{FSM}	A	730/800	50/60Hz Sine Half wave, Non-repetitive 1 cycle peak value
I^2t	I^2t	A^2s	2600	Value for one cycle of surge current
Operating Junction Temperature	Tj	℃	-40～+150	
Storage Temperature	Tstg	℃	-40～+125	
Isolation Breakdown Voltage (R.M.S.)	Viso	V	2500	Terminals to case, AC 1 minute
Mounting Torque（M4）		N･m	1.5	Recommended Torque:1.0～1.4N･m
Mass		g	24	Typical Value

Table 1 Maximum Ratings

The maximum rating is a value that must not be used exceeding this specification at under any condition.

1. Repetitive Peak Reverse Voltage
   This is peak value of applicable repetitive reverse voltage to between anode and cathode. Even under any conditions, it must be 1600V or less. This voltage includes spike voltage such as noise.
2. Non-repetitive Peak Reverse Voltage
   This is overvoltage peak value of applicable non-repetitive reverse voltage to between anode and cathode.
3. DC Output Current
   This is maximum DC output value of operable current at 3 phase full wave rectified circuit. The case temperature at this time must do to 110degC or less.
4. Surge Forward Current
   This is peak value of operable instantaneous forward current (Anode⇒ cathode). Normally, this condition is single phase, half wave 50/60Hz and non-repetitive one cycle.
5. I^2t
   This is combinative value of operable instantaneous forward current and the corresponding time. This means value of operable current within one cycle of commercial power. This value are using for choosing the circuit breaker or the fuse by coordination protect.
6. Operating Junction Temperature
   This value is junction temperature of device for acceptable in driving.

7. Storage Temperature
   This is temperature range of device for acceptable storage and transport without power.
8. Isolation Breakdown Voltage
   This is root means square value of voltage for acceptable sinusoidal voltage at between mounting side and terminal. These all terminals should be connected.
9. Mounting Torque
   This is maximum torque for tightening the module and heatsink (or cable) by the specified screw. Normally, we recommend using within recommendation.

2-2. Electrical Characteristics

Here is explanation of DF60NB160's electrical characteristics.

Items	Symbols	Unit	Values			Conditions
			Min.	Typ.	Max.	
Repetitive Peak Reverse Current	I_{RRM}	mA			8.0	Tj=150℃、V_{RRM} =1600V
Forward Voltage Drop	V_{FM}	V		1.08	1.30	Tj=25 ℃ I_{FM} =60A, Instant measurement
Threshold Voltage	$VT_{(T0)}$	V			0.91	Tj=150℃
Slope Resistance	rt	mΩ			4.9	Tj=150℃
Thermal Impedance	Rth(j-c)	℃/W			0.25	Junction to Case per one module
Interface Thermal Resistance	Rth(c-f)	℃/W			0.2	Case to Heatsink Thermal conductivity (Silicon grease)≒9×10-3[W/cm･℃]

Table 2 Electrical characteristics

The electrical characteristics are value of showing the performance at under conditions.

1. Repetitive Peak Reverse Current
   This is peak value of maximum leakage current at applying the reverse voltage to between anode and cathode.
2. Forward Voltage Drop
   This is voltage drop value of occurring to between anode and cathode at applying the forward current.
3. Threshold Voltage
   This is maximum on-state voltage at conditions of designation.
4. Slope Resistance
   This is slop resistance at conditions of designation.
5. Thermal Impedance
   This is showing the value that is hindering the flow of heat from junction. Normally, this value divides the temperature difference of between junction and the case by the corresponding power loss.

6. Interface Thermal Resistance

This is showing the value that is hindering the flow of heat between case and heatsink. Normally, this value divides the temperature difference of between case and heatsink by the corresponding power loss.

2-3. Comparison data between existing model vs. DIP type module

The DF-NB is very compact in comparison with existing module, but characteristics are almost same as existing module.

Items	Symbols	Unit	DF60NB160 (New)	DF60LA/LB160 (Existing)	Condition
Repetitive Peak Reverse Voltage	V_{RRM}	V	1600	1600	
Non-Repetitive Peak Reverse Voltage	V_{RSM}	V	1700	1700	
Output current	I_D	A	60 (T_C=110degC)	60 (T_C=111degC)	3 phase Full wave rectifier circuit
Surge forward current	I_{FMS}	A	730/800	730/800	50/60Hz Sine Half wave, Non-repetitive 1 cycle peak value
I^2t	I^2t	A^2s	2600	2600	Value for one cycle of surge current
Operating Junction Temperature	Tj	℃	-40～+150	-40～+150	
Storage Temperature	T_{stg}	℃	-40～+125	-40～+125	
Isolation Breakdown Voltage (R.M.S.)	V_{ISO}	V	2500	2500	Terminals to case, AC 1 minute
Mass	-	g	24	100	Typical value

Table 3 Comparison data for Maximum Rating

Items	Symbols	Unit	DF60NB160 (New) Maximum	DF60LA/LB160 (Existing) Maximum	Condition
Repetitive Peak Reverse Current	I_{RRM}	mA	8	8	Tj=150℃、V_{RRM} =1600V
Forward Voltage Drop	V_{FM}	V	1.3	1.3	Tj=25℃ I_{FM} =60A, Instant measurement
Thermal Impedance	Rth(j-c)	℃ /W	0.25	0.25	Junction to Case per one module
Interface Thermal Resistance	Rth(c-f)	℃ /W	0.2	0.1	Case to Heatsink Thermal conductivity (Silicon grease) ≒9×10-3[W/cm・℃]

Table 4 Comparison data for electrical characteristics

3. Reliability

The reliability test of our semiconductor products taking into consideration the environment in the market consists of environmental test and durability test so that simulates or accelerates voltage, current, stress, temperature, mechanical stress as actual operation.
That reliability test conditions are implemented in accordance with the Japan Electronics and Information Technology Industries Association Standard (JEITA).

3-1. Comparison power cycle data between existing and new

The power cycle test (Hereinafter called “P/C test”) is one of durability test.
We are implemented in accordance with the EIAJ-4701.
The P/C test is applying the power to all devices, and changes the junction temperature (Tj)

> The condition and criteria of power cycle test are different with each competitor. So, there are important to judge by market results, structure or comparison test results because it is difficult to judge relative merits with other competitor’s products by comparing only the cycle number because test condition and criteria of power cycle depend on manufacturer.

Test condition
IF(AV)=60A, ⊿Tj=100℃, Cycle number=5000cycle
Ability
DF60LB160‥‥14000cycle
DF60NB160‥‥80000cycle（Ongoing now）

The test is still ongoing. But DF60NB160 ability is already 5 times bigger than existing package under ⊿Tj=100℃ condition at present result.

3-2. Comparison Heat cycle data between existing and new

The heat cycle test (Hereinafter called “H/C test”) is one of durability test.
We are implemented in accordance with the EIAJ-4701.
The H/C test is not applying the power, and changes the environmental temperature.
The condition and criteria is different with each competitor like P/C test.

Test condition
One cycle is -40℃(60min)⇒25℃(10min)⇒125℃(60min)⇒25℃(10min), then one cycle continues 500cycle.
Ability
DF60LB160‥‥700cycle
DF60NB160‥‥1000cycle（Ongoing now）

The test is still ongoing. But DF60NB160 ability is already 1.2 times bigger than existing package under ⊿Tj=165℃ condition at present result.

4. Usage Notes

4-1. Storage and Transport

We recommend to store the module at the following condition.

Temperature : 5～35℃
Humidity : 45～75%
Do not store in lot of dust, extreme temperature fluctuation and corrosive gas.

If you store the module at long time (More than 1 year), please take measures for humidity. Please check the visual for being no damage and no sttain at using.

Do not drop and turn over, please reduce mechanical shock and vibration as much as possible, during transportation. And also please keep dry. There are reasons for breaking the module.

4-2. Environment for use

Do not use at the following environment absolutely because this can cause serious accident.

(1) Place of adhering water and organic solvent
(2) Place of generating corrosive gas
(3) Place of generating explosive gas
(4) Place within dust

4-3. Flammability

The resin of DIP type module is using 94-V0 of UL standard authorization. Please note that is non flammability.

4-4. Information for designing the PCB

4-4-1. Pattern width example

Pattern width is different by pattern temperature and thickness of PCB that you use.

Table 5 is summarizes the required pattern width and temperature rise at each pattern thickness based on JIC C 5012. When it is difficult to keep the pattern width at one side pattern PCB, you must use double side pattern PCB or multilayer PCB.

Also you must check whether the pattern width and temperature rise pass the internal standard.

Pattern width [μm]	Required pattern width [mm]		
	10℃ rise	20℃ rise	30℃ rise
35	30	20	14
70	22	14	10
105	18	12	9

Table 5 Required pattern width and temperature rise at each pattern thickness (At 60A)

4-4-2. Recommended hole size and land

Lead of DF60NB160 is width 1.5mm and thickness 0.8mm. So, recommended hole size is 2mm (Finished diameter).

Figure 9 is recommended layout.

When DF60NB160 assembles to PCB after mounting to heatsink, hole for fixing screw is not necessary. The part number is showing to the heatsink side too.

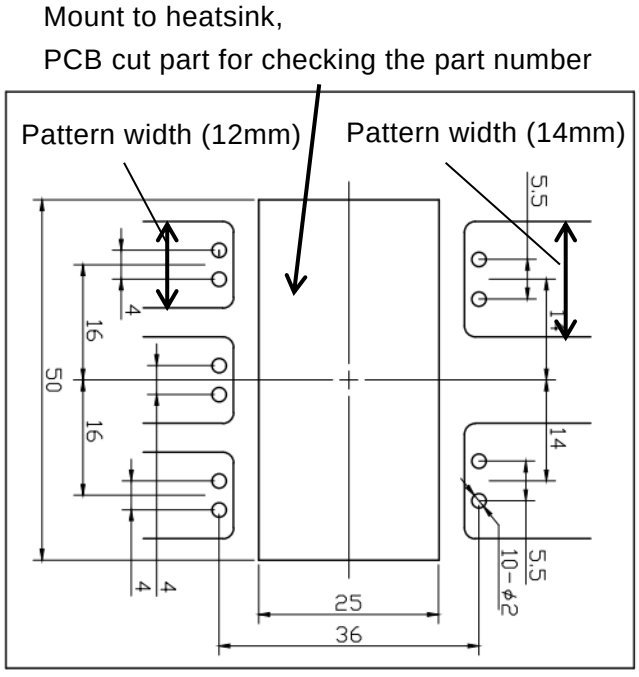


Fig.7 PCB Layout example (105μm thickness, double side PCB)

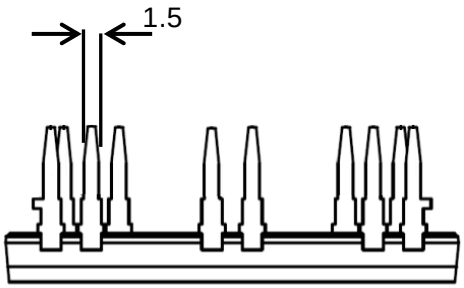


Fig.8-1 DF60NB160 lead width

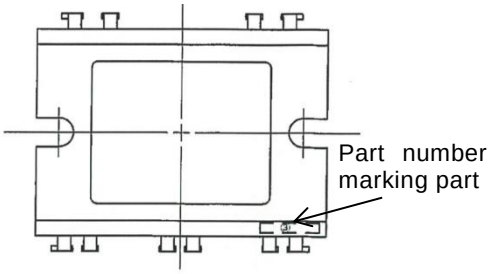


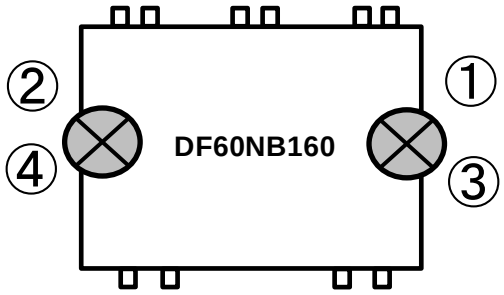
Fig.8-2. DF60NB160 part number marking

4-5. How to mount to heatsink (Tightening order, and apply grease)

4-5-1. Mounting torque at mounting to heatsink

Mounting screw size of DF60NB160 is M4. Recommended mounting torque is 1.0~1.4 N・m as specification of mounting torque is 1.5 N・m.

If customer tightens the screw by unbalance at mounting, module may have stress and there is possibility of damage. So customer tightens the screw at less than 20% of rated torque provisionally. Then please tighten the screw at rated torque after that.



① Tighten at 0.3N・m
② Tighten at 0.3N・m
③ Tighten at 1.4N・m
④ Tighten at 1.4N・m

Fig.9 Tightening order and recommended torque

4-5-2. Flatness of heatsink

Recommendation of heatsink flatness and surface roughness is the following.

If customer uses heatsink that is exceeding the recommendation, that cause an increase in the interface thermal resistance. And then, if flatness becomes convex, module has stress and there is possibility of damage.

・Surface roughness : Less than 6S (6μm)
・Flatness : Less than 50μm

4-5-3. Applied the thermal grease

Please apply the thermal grease uniformly to the base side of module, and the contact side of heatsink absolutely. But you must choose the thermal grease that performs no change in quality and no characteristics deterioration at rated temperature. We recommend the G747 made by Shin-Etsu chemical and so on. Please apply the thermal grease to an entire base side by thickness of 0.1mm to 0.2mm. If thermal grease protruded out of the module, please clean that up.

4-5-4. Contact resistance between case and heatsink

Contact resistance between case and heatsink of DF60NB160 is 0.2℃/W (※1).

(※1…Use G747 (0.9W/m・K))

4-6. Soldering conditions

Please solder by reflow soldering or manual soldering.

We are doing the resistance to soldering heat test by following condition.

Soldering temperature 260℃±5℃

Soldering time 10s±1s

One time

So if customer condition is lower than those, it is no problem.

For the manual soldering, customer has to evaluate sufficiently because condition is vary greatly depending on kind of the soldering iron, power, PCB layout, etc.

Customer must pay attention to what temperature of the lead base of the DF60NB160 becomes 200℃ or less at soldering because it is the allowable temperature of the exterior resin.

Please do not apply the mechanical stress by modifying the place after soldering.

Please do soldering after heatsink fixies.

Figure 10 is recommendation profile of DIP type module.

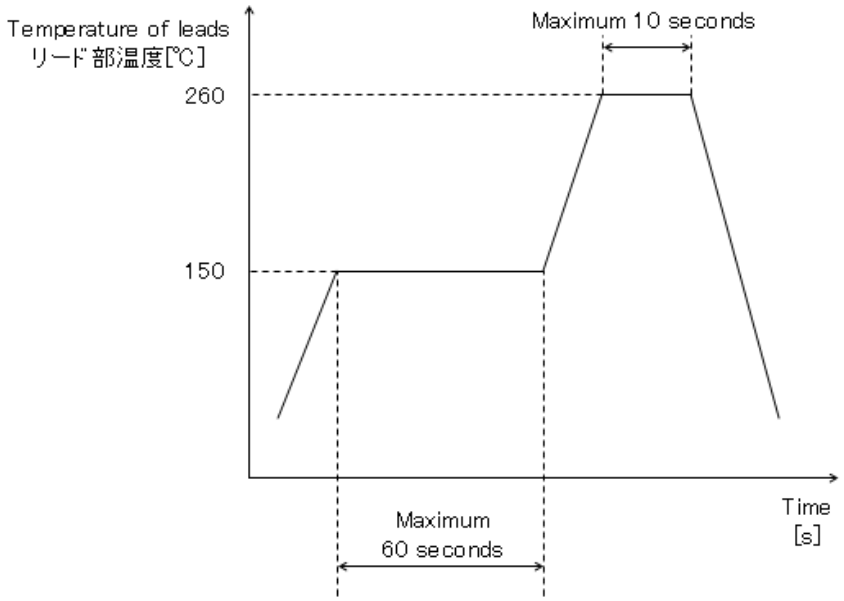


Fig.10 DIP type module recommendation profile (Flow soldering)

4-7. Cleaning

Please note to the following point for cleaning the flux after soldering.

- Please take short time for immersing into cleaning solution
- Please do not scrub the marking before cleaning solution is drying.
- We recommend using the immersion washing and steam washing for washing method.
  If you use ultrasonic washing, please refer to the following.

  - Frequency : 27 to 29kHz
  - Ultrasonic power : 15W/1 time
  - Cleaning time : less than 30sec
  - Other : Do not contact the PCB and/or device to vibrator directly

4-8. Lead forming and cutting

When you bend lead, please fix the lead of between device and bending point, which is more than 2mm from case. If you do not do this, device may have stress.

And also please provide the structure that fixes the lead part if you do the lead forming and/or cutting by tools.

4-9. Creepage distance

Table 6 and 7 is showing the creepage distance of DF60NB160.
The creepage distance is changing by heatsink form that customer uses.
The standard for creepage distance is established by IEC or UL etc., so please check whether the creepage distance is keeping the standard of equipment that customer uses.
For the reference, excerpts of each standard are shown in Table 8 and 9 below.

Part number	Measurement parts	Clearance	Creepage distance
DF60NB160	Lead-Heatsink	3.25mm	5.32mm
	Lead-Lead	9.20mm	9.80mm

Table 6 In case of using the flat type heatsink

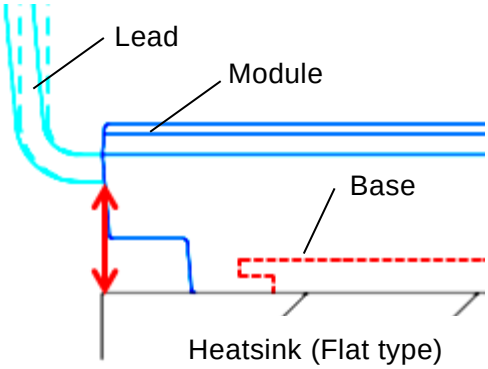


Fig.11-1 Lead-Heatsink clearance

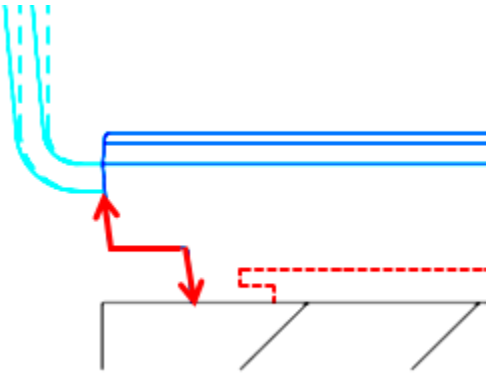


Fig.11-2 Lead-Heatsink creepage distance

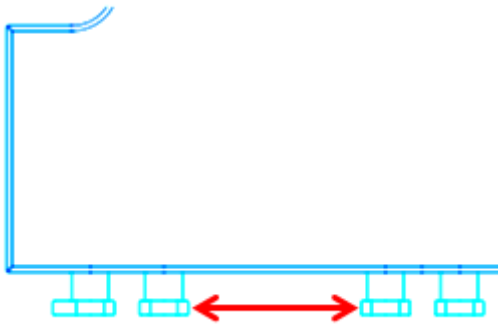


Fig.12-1 Lead-Lead clearance

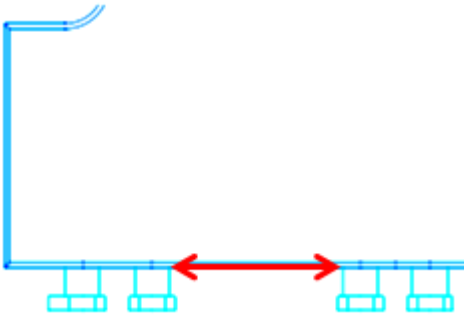


Fig.12-2 Lead-Lead creepage distance

Part number	Measurement parts	Clearance	Creepage distance
DF60NB160	Lead-Heatsink	6.68mm	7.44mm
	Lead-Lead	9.20mm	9.80mm

Table 7 In case of using the convex type heatsink

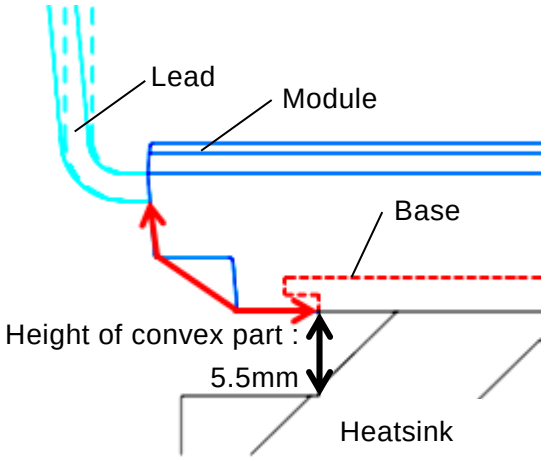


Fig. 13-1 Lead-Heatsink clearance

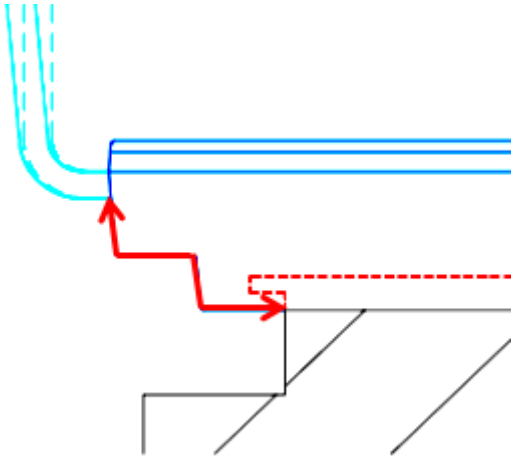


Fig. 13-2 Lead-Heatsink creepage distance

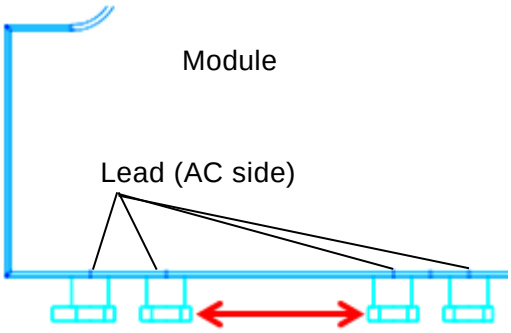


Fig. 14-1 Lead-Lead clearance

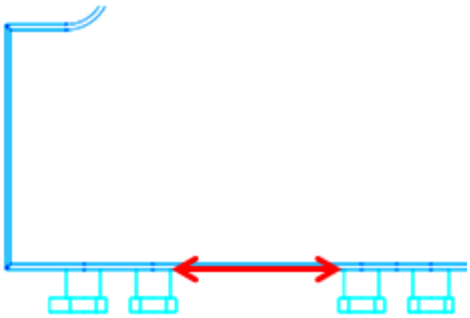


Fig. 14-2 Lead-Lead creepage distance

Clearance			Creepage distance	
Overvoltage category	System voltage[V] (r.m.s. or DC)	Pollution severity 3	Operating voltage[V] (r.m.s. or DC)	Pollution severity 3 Insulating material group II
II	150	0.8mm min	250	3.6mm min
	300	1.5mm min	320	4.5mm min
	600	3.0mm min	400	5.6mm min
	-	-	500	7.1mm min

Table 8 Clearance and Creepage distance by UL840 (Excerpt)

Clearance			Creepage distance	
Overvoltage category	System voltage[V] (Peak or DC)	Pollution severity 3 Basic insulation Supplementary insulation	Operating voltage[V] (r.m.s. or DC)	Pollution severity 3 Insulating material group II
II	280	1.4mm min	200	2.8mm min
	420	1.9mm min	250	3.6mm min
	700	2.5mm min	300	4.5mm min
	-	-	400	5.6mm min

Table 9 Clearance and Creepage distance by IEC 60950 (Excerpt)

In case of using DF60NB160 at 400V line, the creepage distance is not enough for each standard at using flat type heatsink. So you must use convex type heatsink.

But these clearance and creepage distance depends on operating voltage of equipment or PCB, pollution severity and insulating material group, etc., so, you must check the standard by following your condition and design.

5. Design considerations

In using the DF-NB series, please refer to important point below.

5-1. Inrush current

At power up, big current flows to diode for charging the big capacitor that is using for getting stable power at back of converter. So some circuits are using the inrush current prevention logic for reducing this big current. So customer must check whether inrush current is within specification.

In datasheet, this inrush current is showing by surge forward current (I_{FSM}) and I^2t.

The surge forward current is the maximum value of current applied transiently literally, and current has to be less than this value in any case.

The I^2t is the combination rating of current and time that apply transiently like surge. In this case, there is possibility that rating is out of specification even if applying current is small as time is long.

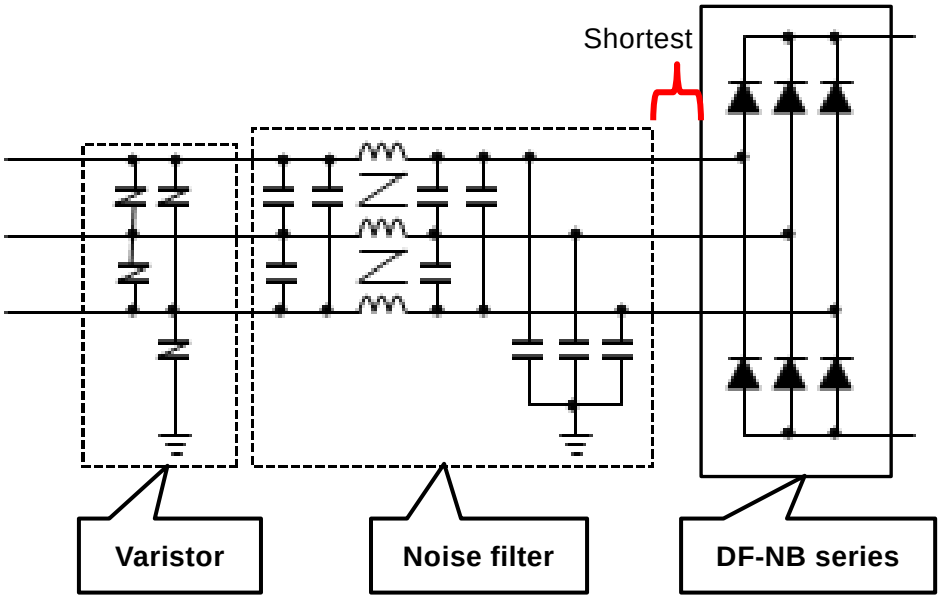


Fig.15 Countermeasure circuit for input and point for pattern design

5-2. Lightning surge and power line noise

DF-NB series connects to AC power line directly. So, there is possibility to be affected by lightning surge or power line noise. For example, when the transmission line was struck by lightning, there is possibility that a few kV to a few ten kV voltages would be applied to DF-NB series. Also there is possibility that several kV voltages would be applied by external noise at unstable power line area. If this voltage applies to DF-NB series, there is possibility of malfunction and damage. So customer should use the lightning surge suppression components (Such as varistor) and noise suppression components for that countermeasure.

5-3. Point of pattern design (Input line)

It is products that used at the main power line in the pattern design of the PCB. In the pattern design of the PCB, this product uses to the main power line, so that customer has to design the pattern so as not to become noise generator at line.

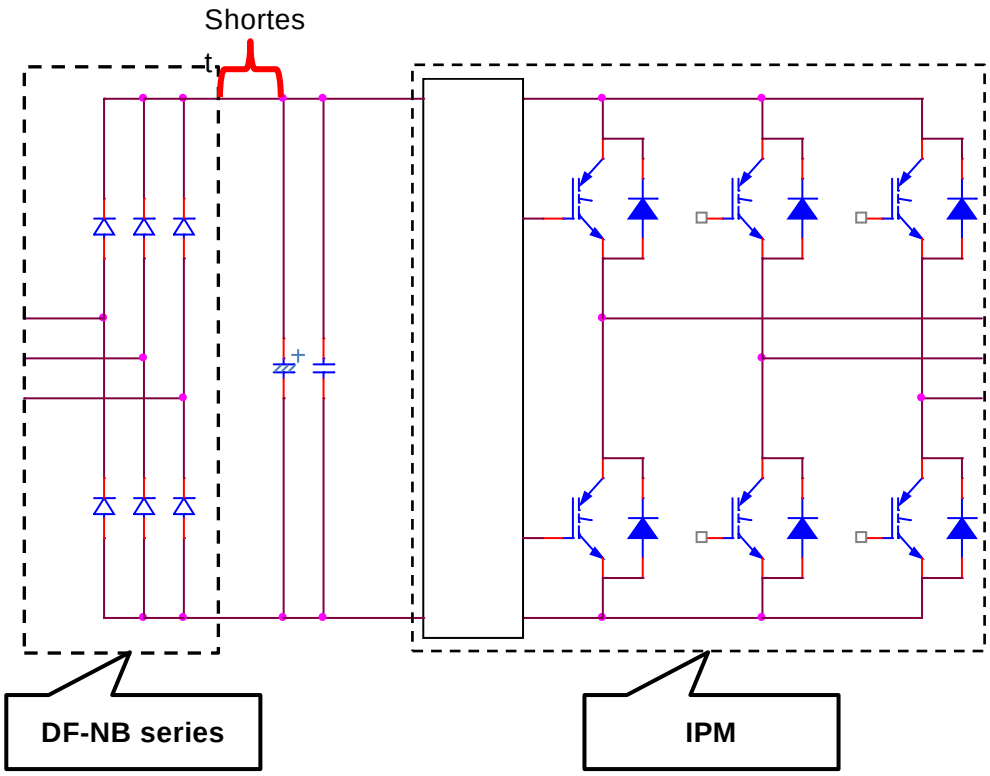


Fig.16 Point of pattern design

If there is possibility that noise applies from power line and when customer uses those countermeasure components, customer should put near the device, and customer should design by shortest line for getting performance fully.

5-4. Point of pattern design (Output line)

DF-NB series is diode bridge module. So, there is no possibility to become to noise generator. However, there are cases where noise by high speed switching of inverter etc. injects.

Traditional circuit has aluminum electrolytic capacitor or snubber capacitor to between DF-NB series and IPM for getting stable DC power after smoothing, or countermeasure of IPM switching noise.

For getting performance of these capacitors fully, customer should design by shortest line for these capacitors.

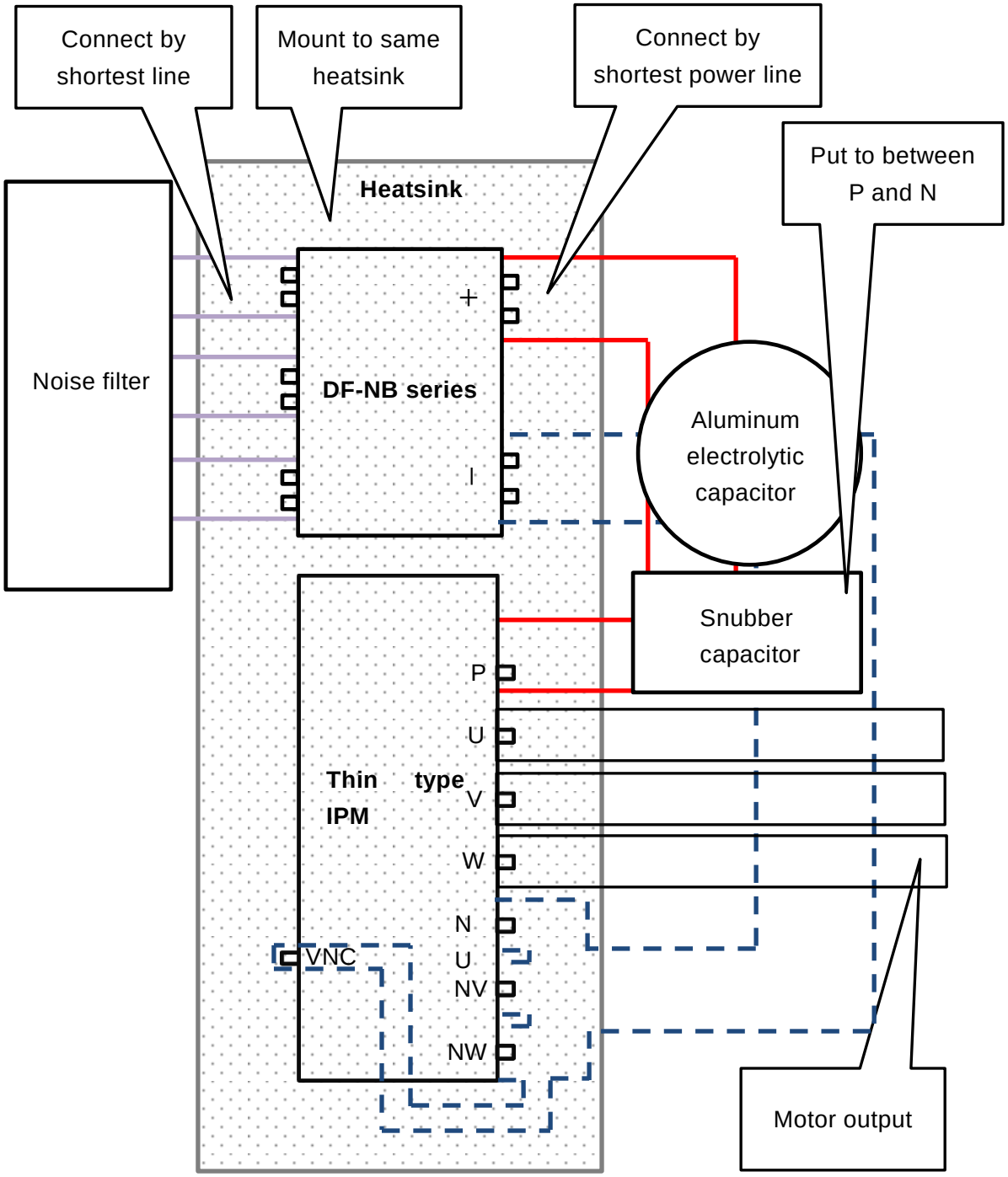


Fig.20 Mount image of DF-NB series

6. ＜Attention＞

- Although we make every effort to improve quality and reliability, semiconductor products may fail or malfunction due to various factors.
- When using this product, safety measures should be taken for the equipment on which the product will be used, such as redundancy design, design for prevention of the spread of fire, design for prevention of malfunction, etc. in which safety is taken into consideration, so that no accident resulting in personal injury or death, or no damages due to fire, will occur.
- We will not be held responsible for any accidents or damages that have occurred due to use exceeding the rated values or non-observance of precautions.
- If a product described in this material is subject to regulations under the Foreign Exchange and Foreign Trade Act, permission for export is required to be obtained from the Government of Japan under the said Act, in order to export the product.
- Do not use the product for purposes of development, etc. of weapons of mass destruction or for purposes of military utilization, etc.
- Consult us if you have any questions about the product.