2DMB Series
Gate Driver Module

Overview

The dual channel Gate driver module (2DMB Series) is composed of an insulating type DC / DC converter and the gate drive circuit.
DM series allows you to easily develop gate drive circuits by externally connecting gate circuits, DESAT protection circuits, etc.

Features

- Built-in isolated DC / DC converter and gate drive circuit.
- DC/DC converter input voltage : 13～28V.
- Signal input voltage : 3.3V, 5V
- Low parasitic capacitance (about 12pF) ; highly resistant to common-mode noise.
- The isolation for primary-secondary signal used fast response isolator.
- Input-output dielectric withstand voltage: AC5000V
- Output CH1-Output CH2 dielectric withstand voltage: AC4000V
- Input-output insulation distance: 14 mm (clearance・creepage)
- Output CH1-Output CH2 insulation distance: 12mm(creepage), 7mm(clearance)
- Very short delays of about 100 ns, providing compatibility with high frequency.
- DC/DC converter incorporating overcurrent protection and overheating protection.
- Gate drive circuits incorporating a half-bridge mode(HBM), a fault signal output function, a soft-turn off function, a low-voltage malfunction prevention function (UVLO, under-voltage lockout), and a DESAT protection function.

The example of application circuits and parts value which are indicated to this application note aim at assistance of a design. Therefore, external parts variation or user operating conditions are not fully taken into consideration. Please take parts variation, operating conditions into consideration when designing.

Contents

1. Application examples

1.1 Circuit example (For IGBT)

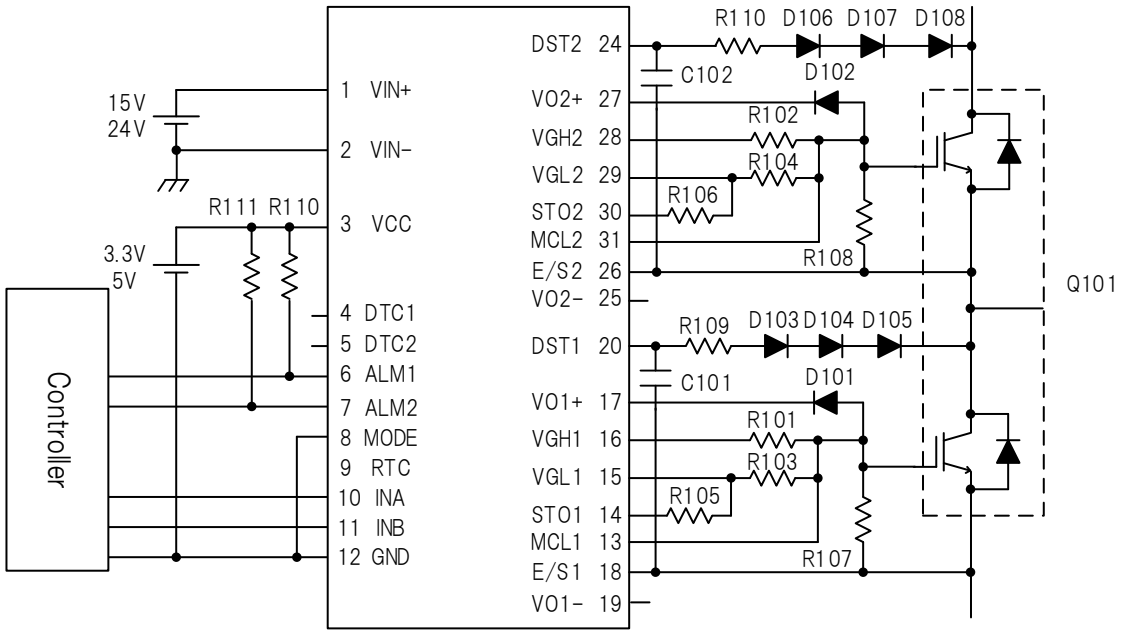


Figure 1.1 Circuit example

1.2 Parts example (For IGBT)

Symblo	Description	Part No.	Manufacturer
Q101			
D101,102	Diode	RB400VAM-50	ROHM
D103-108	Diode	CMF05	TOSHIBA
C101,102	Capactior	100pF 25V	
R101-104	Resistor	1.0Ω 4W	
R105,106	Resistor	16Ω 0.75W	
R107,108	Resistor	10kΩ 0.125W	
R109,110	Resistor	1kΩ 0.1W	
R110,111	Resistor	10kΩ 0.1W	

1.3 Circuit example (For SiC-MOSFET)

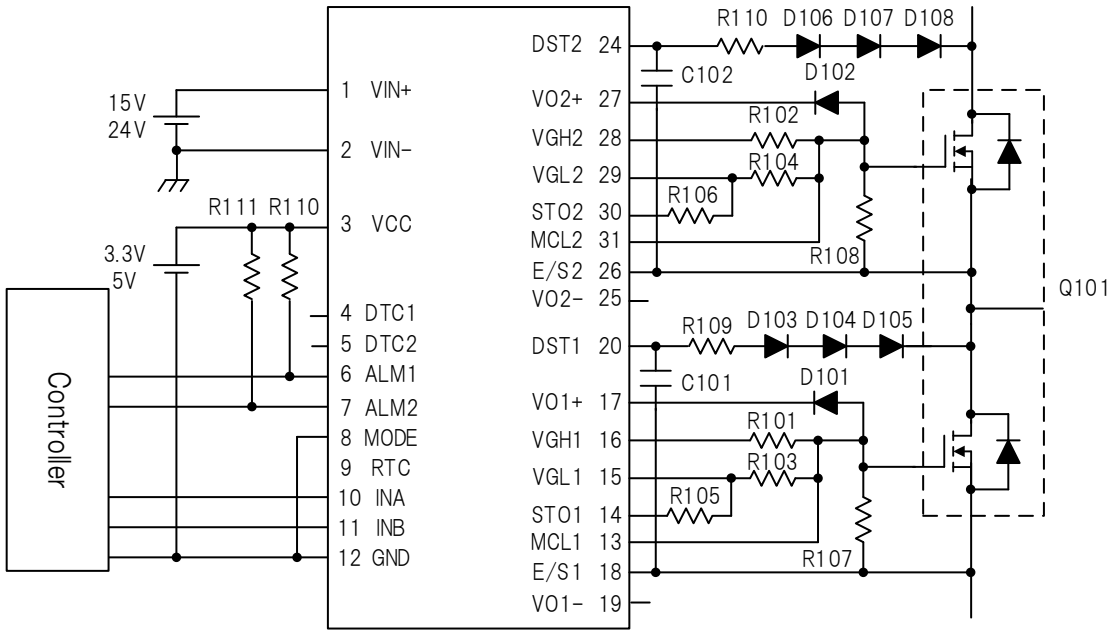


Figure 1.2 Circuit example

1.4 Parts example (For SiC-MOSFET)

Symblo	Description	Part No.	Manufacturer
Q101			
D101,102	Diode	RB400VAM-50	ROHM
D103-108	Diode	CMF05	TOSHIBA
C101,102	Capactior	100pF 25V	
R101-104	Resistor	1.0Ω 4W	
R105,106	Resistor	16Ω 0.75W	
R107,108	Resistor	10kΩ 0.125W	
R109,110	Resistor	1kΩ 0.1W	
R110,111	Resistor	10kΩ 0.1W	

1.5 Block diagram

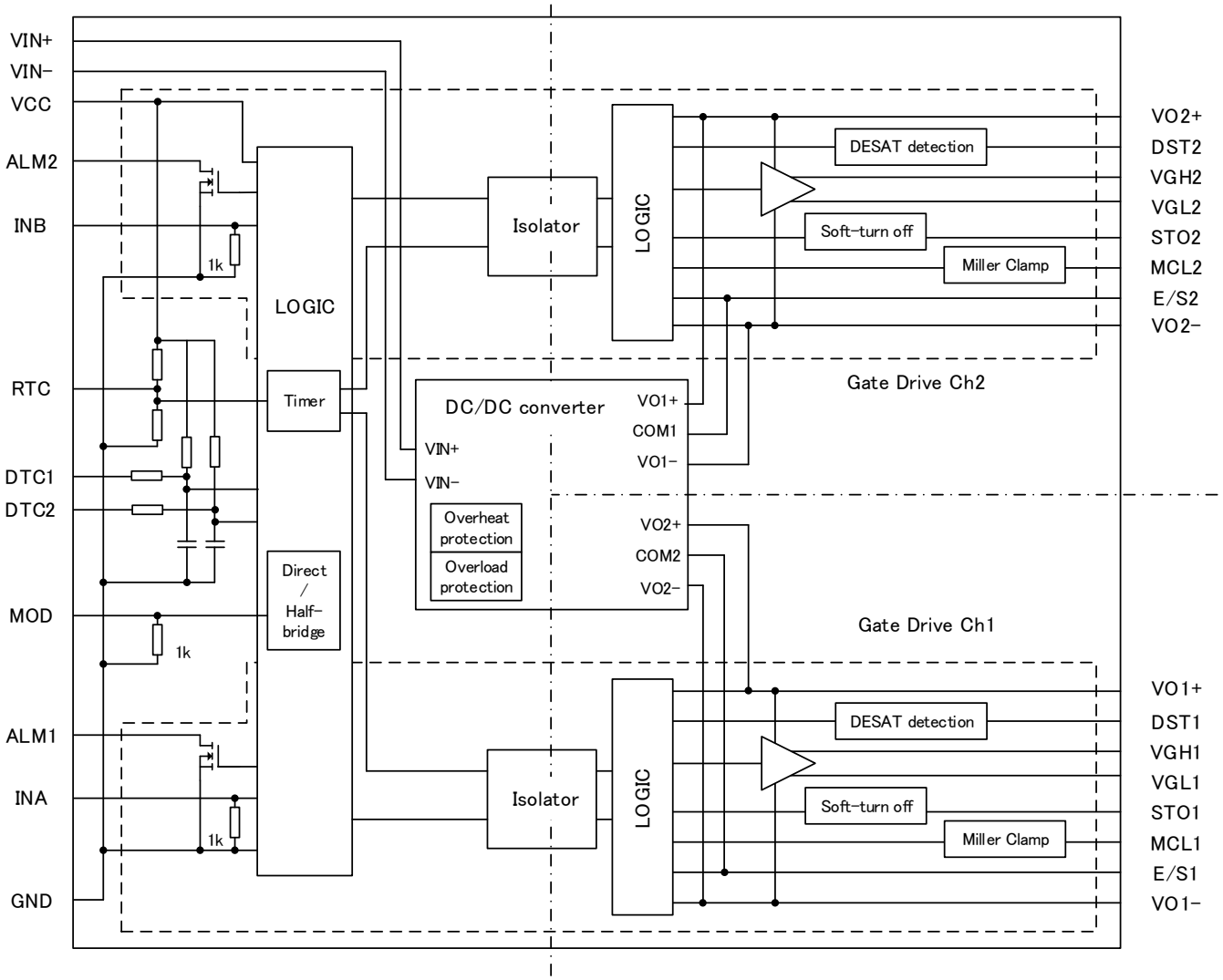


Figure 1.3 Internal block diagram

2. Pin functions and descriptions

2.1 Pin functions

Input side

Pin No.	Name	CH	Explanation of pins
1	VIN+	Common	Power supply for DC/DC converter(+)
2	VIN−	Common	Power supply for DC/DC converter(−)
3	VCC	−	Power supply for drive circuit
4	DTC1	CH1	Dead time adjustment
5	DTC2	CH2	Dead time adjustment
6	ALM1	CH1	Alarm signal output
7	ALM2	CH2	Alarm signal output
8	MOD	−	Mode select
9	RTC	−	Recovery time of protection circuit control
10	INA	CH1	Control input A
11	INB	CH2	Control input B
12	GND	−	Ground for drive circuit

Output side

Pin No.	Name	CH	Explanation of pins
13	MCL1	CH1	Miller clamp pin
14	STO1	CH1	Soft turn off pin
15	VGL1	CH1	Gate OFF side pin
16	VGH1	CH1	Gate ON side pin
17	VO1+	CH1	DC/DC converter output pin
18	E/S1	CH1	Emitter・source connection pin
19	VO1−	CH1	DC/DC converter output pin
20	DST1	CH1	Desaturation protection pin
21	NONE	−	None
22	NONE	−	None
23	NONE	−	None
24	DST2	CH2	Desaturation protection pin
25	VO2−	CH2	DC/DC converter output pin
26	E/S2	CH2	Emitter・source connection pin
27	VO2+	CH2	DC/DC converter output pin
28	VGH2	CH2	Gate ON side pin
29	VGL2	CH2	Gate OFF side pin
30	STO2	CH2	Soft turn off pin
31	MCL2	CH2	Miller clamp pin

2.2 Pin descriptions

(1) VIN(+), VIN(−)･･･Power supply pin for DC/DC converter
The Vin(+) and Vin(−) pin is a pin used to the power supply for DC/DC converter.

(2) GND･･･Ground pin for drive circuit
The GND pin is a used to the control circuits for gate driving.

(3) MOD,INA, INB･･･Mode switching pin, Control input pin
The INA, INB and MOD pin is a pin used to determine output logic.
Direct mode / Half bridge mode can be switched by MOD pin.
In Half bridge mode, it functions as INA: gate signal, INB: enable signal.
At start up, please INA and INB pin is Low.

MOD	INA	INB	Gate G1	Gate G2	Mode
L	L	X	L	X	Direct mode
L	H	X	H	X	
L	X	L	X	L	
L	X	H	X	H	
H	X	L	L	L	Half bridge mode
H	L	H	L	H	
H	H	H	H	L	

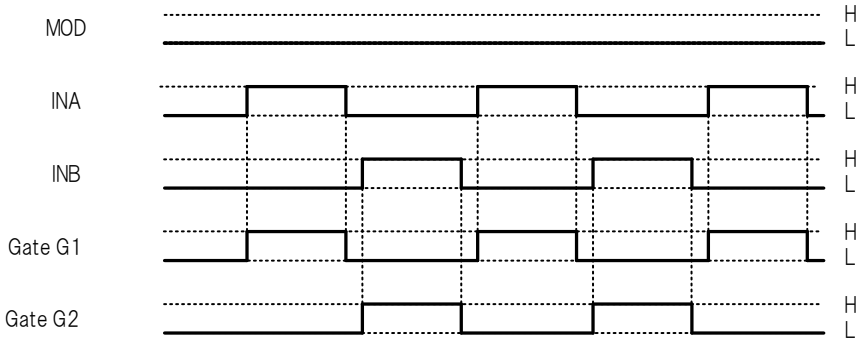


Figure 2.1 Timing chart of Direct mode

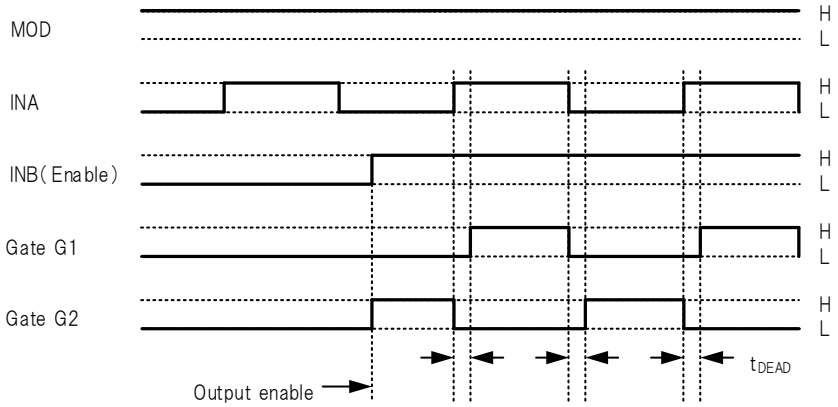


Figure 2.2 Timing chart of Half bridge mode

※Gate G1:Gate output of CH1 side, Gate G2:Gate output of CH2 side

(4) ALM1,2・・・Alarm signal output pin

When abnormality occurs (UVLO, short circuit detected),This pin outputs an alarm signal. (Open-Drain)

In case of check the High signal during normal operation, add a pull-up resistor. (Refer to Figure 1.1 R110,R111)

Status	ALM1,2
While in normal operation	Hi-Z
UVLO, When detecting short circuit	L

(5) DTC1,2・・・Dead time adjustment pin

When half-bridge mode, this pin is adjust the dead time of gate output G1,G2.

When not in use, connection to other circuits is impossible.

(6) RTC・・・Recovery time of protection circuit control pin

When abnormality occurs (UVLO, short circuit detected),this pin is used to adjust the recovery time.

(7) VGH1,2・・・Gate ON side pin

The VGH pin is a pin for gate drive of source. VGH pin connect to the gate pin through gate resistor of ON side.

(8) VGL1,2・・・Gate OFF side pin

The VGL pin is a pin for gate drive of sink. VGL pin connect to the gate pin through gate resistor of OFF side.

(9) STO1,2・・・Soft turn off pin

The STO pin is a pin for gradually decrease gate voltage in operating desaturation protection.

STO pin connect to the gate pin though a resistance value higher than the resistance value connected to VGL 1 and 2. Recommend 10Ω to 47Ω.

(10) MCL1,2・・・Miller clamp pin

The MCL pin is a pin for preventing increase in gate voltage due to the miller current of the power device connected to Gate pin. Please do not connect if not used. Please connect short between MCL1,2-Vo1-,Vo2- If the malfunction due to noise is a concern.

(11) DST1,2・・・DESAT detection pin

The DESAT pin is a pin used to detect desaturation of IGBT/MOSFET. When the DESAT pin voltage exceeds V_{DESAT}, the DESAT function will be activated. This may cause the IC to malfunction in an open state. To avoid such trouble, short-circuit the DESAT pin to the E/S pin if the desaturation protection is not used. For the noise mask time $t_{DESATFIL}$ in order to prevent the wrong detection due to noise is set, please connect a capacitor between DSTx-E/S.

(12) E/S1,2・・・Emitter/source pin

The E/S pin is a pin to be connected to the emitter / source of the power device.

(13) VO1+,VO2+,VO1-,VO2- ・・・DC/DC converter output pin

The VO1+,VO2+,VO1-,VO2- pin is a output pin of built-in DC/DC converter. If necessary, connect a capacitor.

2.3 Operation truth table

No.	Status	Input						Output(CH1)					Output(CH2)				
		VO+	DST1	DST2	MOD	INA	INB	ALM1	VGH1	VGL1	STO1	MLC1	ALM2	VGH2	VGL2	STO2	MLC2
1	VOx+ UVLO	UVLO	X	X	X	X	X	L	Hi-Z	Hi-Z	Hi-Z	Hi-Z	L	Hi-Z	Hi-Z	Hi-Z	Hi-Z
2	Normal operation (Direct Mode)	○	X	L	L	X	L	X	X	X	X	X	Hi-Z	Hi-Z	L	L	L
3		○	X	L	L	X	H	X	X	X	X	X	Hi-Z	H	Hi-Z	Hi-Z	Hi-Z
4		○	L	X	L	L	X	Hi-Z	Hi-Z	L	L	L	X	X	X	X	X
5		○	L	X	L	H	X	Hi-Z	H	Hi-Z	Hi-Z	Hi-Z	X	X	X	X	X
6	Normal operation (Half Bridge Mode)	○	L	L	H	X	L	Hi-Z	Hi-Z	L	L	L	Hi-Z	Hi-Z	L	L	L
7		○	L	L	H	L	H	Hi-Z	Hi-Z	L	L	L	Hi-Z	H	Hi-Z	Hi-Z	Hi-Z
8		○	L	L	H	H	H	Hi-Z	H	Hi-Z	Hi-Z	Hi-Z	Hi-Z	Hi-Z	L	L	L
9	Desaturation protection 1	○	L	Hi-Z	L	X	L	Hi-Z	X	X	X	X	Hi-Z	Hi-Z	Hi-Z	L	L
10		○	L	Hi-Z	L	X	H	Hi-Z	X	X	X	X	L	Hi-Z	Hi-Z	L	L
11		○	L	Hi-Z	H	L	H	Hi-Z	Hi-Z	L	L	L	L	Hi-Z	Hi-Z	L	L
12		○	L	Hi-Z	H	H	H	Hi-Z	H	Hi-Z	Hi-Z	Hi-Z	Hi-Z	Hi-Z	Hi-Z	L	L
13	Desaturation protection 2	○	Hi-Z	X	L	L	X	Hi-Z	Hi-Z	Hi-Z	L	L	Hi-Z	X	X	X	X
14		○	Hi-Z	L	L	H	X	L	Hi-Z	Hi-Z	L	L	Hi-Z	X	X	X	X
15		○	Hi-Z	L	H	L	H	Hi-Z	Hi-Z	Hi-Z	L	L	Hi-Z	H	Hi-Z	Hi-Z	Hi-Z
16		○	Hi-Z	L	H	H	H	L	Hi-Z	Hi-Z	L	L	Hi-Z	Hi-Z	L	L	L

○: VO1,2+ UVLO > UVLO, X: Don't care

2.4 Functional description

(1) Gate voltage rise prevention function (Miller clamp function)

If gate output Gx=L and the Miller clamp pin voltage < V_{CLPON}, the internal MOSFET of the Miller clamp pin turns on.

Gate Gx	MCL1,2	Internal MOSFET of the MCL pin
L	V_{CLPON} or less	ON
L	V_{CLPON} or more	OFF
H	X	OFF

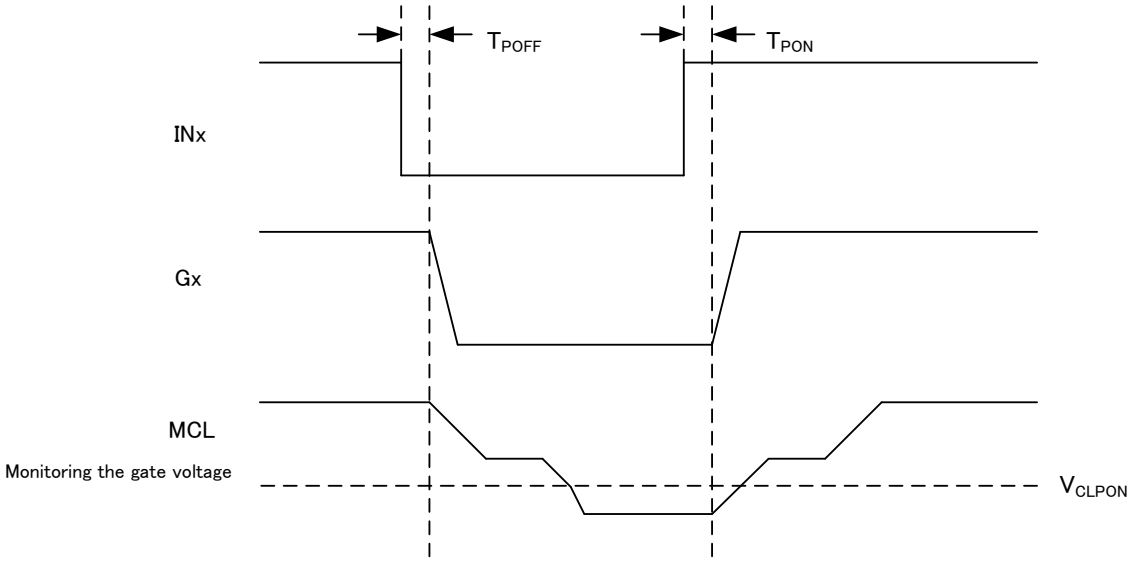


Figure 2.3 Timing chart of Miller clamp function

(2) Undervoltage Lockout (UVLO) function

The control circuit incorporates the undervoltage lockout (UVLO) function on Output voltage(+) sides. When the Output voltage(+) drops to the UVLO ON voltage, the GHx/GLx pin and the ALMx pin both will output the "L"signal. When the Output voltage(+) rises to the UVLO OFF voltage, these pins will be reset.

(3) Short circuit protection function, Soft turn-off function

When the DSTx pin voltage exceeds V_{DESAT}, the short circuit protection function will be activated.
When the short circuit protection function is activated, the gate ON/OFF side pin will be set to the "Hi-Z" level, the STOx pin will be set to the "L" level, and then the ALM pin voltage to the "L" level.
Also, soft turn-off function works to reduce collector/drain voltage surge due to short circuit current.
Short-circuit protection is canceled automatically after an abnormal condition restart time and when the input signal is "L" level.

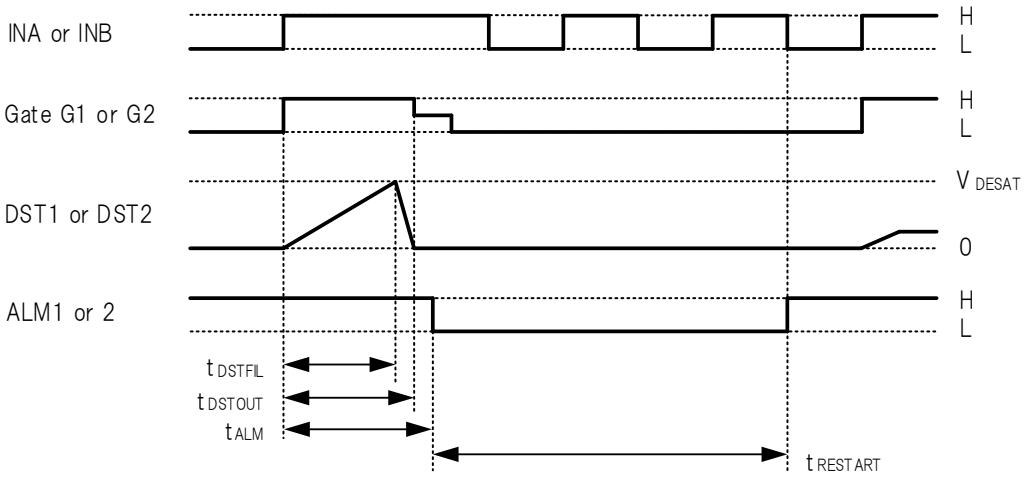


Figure 2.4 Timing chart of short circuit protection function

3. Selection and description of external components

3.1 Abnormal input current protection

The DC/DC converter incorporated in the module does not have a fuse or the function of detecting abnormalities in input current.
In order to ensure safety, be sure to install a fuse on the plus side of input.

3.2 Dead time control

If you want to adjust dead time at half-bridge mode, please refer to the figure below.

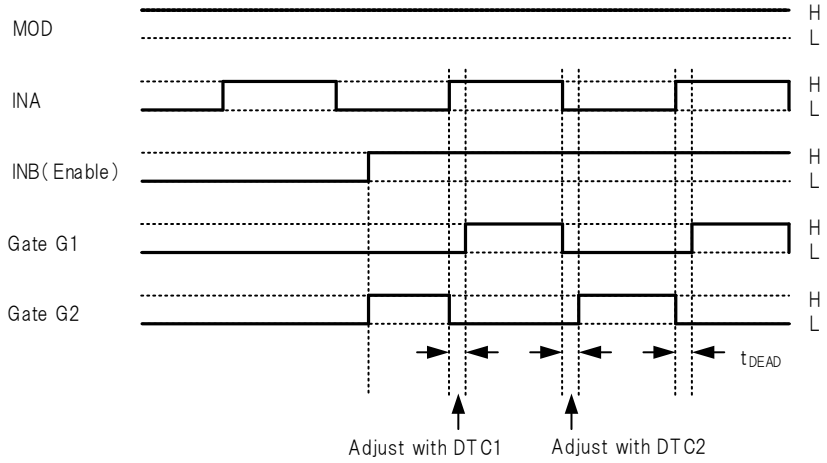
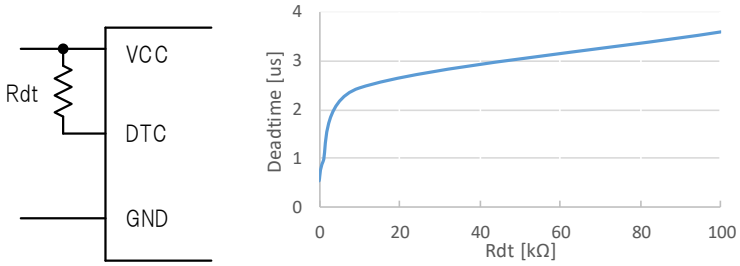
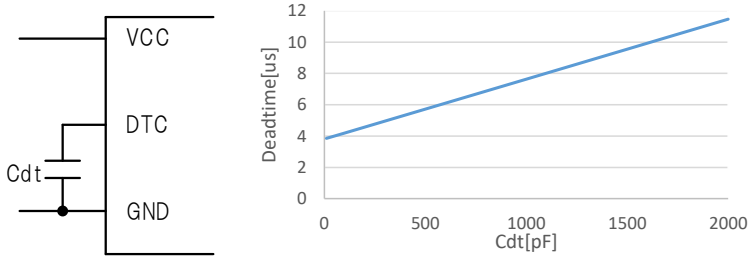


Figure 3.1 Timing chart of Half bridge mode

① Connect a resistor between VCC-DTCx



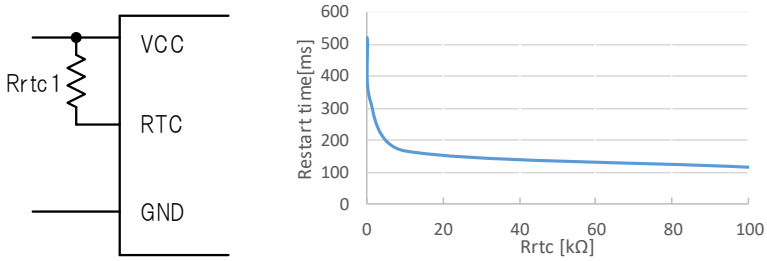
② Connect a capacitor between DTCx-GND



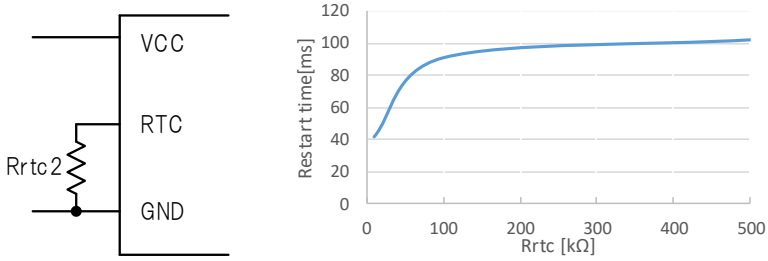
3.3 Recovery time of protection circuit control

If you want to adjust recovery time at short circuit protection, please refer to the figure below.

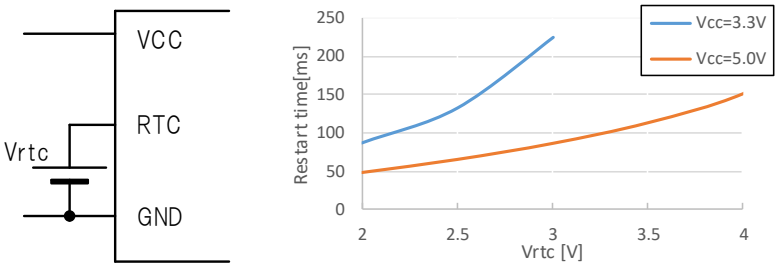
① Connect a resistor between VCC-RTCx



② Connect a resistor between RTCx-GND



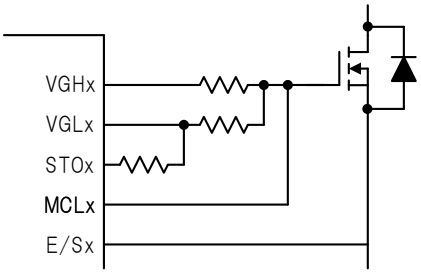
③ Connect the DC voltage between RTC-GND



3.4 Gate circuits

(1) Selecting gate resistors

When selecting a gate resistor, take into consideration surge voltage, noise, etc., of the elements to be connected. STOx pin connect a resistor, as shown below. (Figure 3.1)



※MCLx pin no connect, When not in use of miller clamp function.

Figure 3.2 Gate resistor connection

(2) Maximum electric power and pulse capacity

Since pulse current flows through gate resistors, their pulse power capacity must be fully considered.
For the pulse capacity, contact the relevant resistor manufacturer(s).
The operating electrical power of resistors must be set to around 50% or less of their rated electrical power, and care must be taken for component temperatures during use.

(3) Measures against opens in gate circuits

If a failure occurs in a drive circuit or if a gate circuit becomes open, the device may break down; therefore, it is recommended that a resistor with a resistance of around several dozen kilo-ohms should be connected between gates and emitters/sources.

3.5 Output capacitor

When Q is large, adding a capacitor to VOx+ and VOx- stabilizes the gate output characteristic.
Connect as refer to the figure below, if necessary. the capacitor of Maximum connectable is 470uF or less.

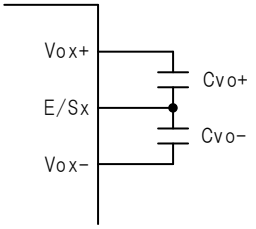


Figure 3.3 External output capacitor

Unit No.	C_{VO+} : C_{VO-}
2DMB51507CC	1:1
2DMB51008CC	1:1
2DMB80407CC	1:2
2DMB80206CC	1:4

ex) 2DMB80407CC
C_{VO+} : C_{VO-} = 4.7uF : 10uF

3.6 DESAT protection circuit

Detection voltage V_{SD}, for which the DESAT protection function works, can be adjusted using V_F of the high-voltage diode and R_{DESAT} of the series-connected resistor. The high-voltage diode to be connected to DESAT must be selected according to the withstand voltages of the elements to be connected and the voltages applied to the elements. Connect 100 Ω or more to the DSTx pin to prevent damage.

Formula:
Detection voltage $V_{SD} = V_{DESAT} - (V_F + R_{DESAT} \times I_{DESAT})$

* The voltage equal to VDS/VCE is impressed on a high-voltage diode. For working voltage, take care to ensure a withstand voltage margin.

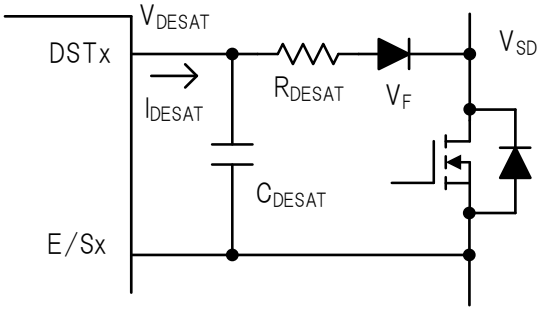


Figure 3.2 DESAT protection circuit

[Design example]
High-voltage diode V_F (I_F=0.25mA) : 2 V
R_{DESAT} resistance : 1000 Ω

Detection voltage V_{SD} $= V_{DESAT} - (V_F + R_{DESAT} \times I_{DESAT}) = 6.35V - (2V + 1000\,\Omega \times 0.24mA)$
$= 4.59V$

Also, DESAT detection filter time (t_{DSTFIL}) can be adjusted by C_{DESAT} connected in parallel with DSTx pin and E / Sx.

Formula:

$t_{DSTFIL} = C_{DESAT} \times V_{DESAT} / I_{DESAT}$

【Design examle】

External capacitor C_{DESAT} : 150pF

$t_{DSTFIL} = C_{DESAT} \times V_{DESAT} / I_{DESAT}$

$= 150pF \times 6.35V / 240uA$

$\fallingdotseq 3.97us$

Adjust C_{DESAT} or Gate resistor as shown below to prevent DESAT protection malfunction in normal operation.

$t_{DSTFIL} > t_{VCEFALL}$

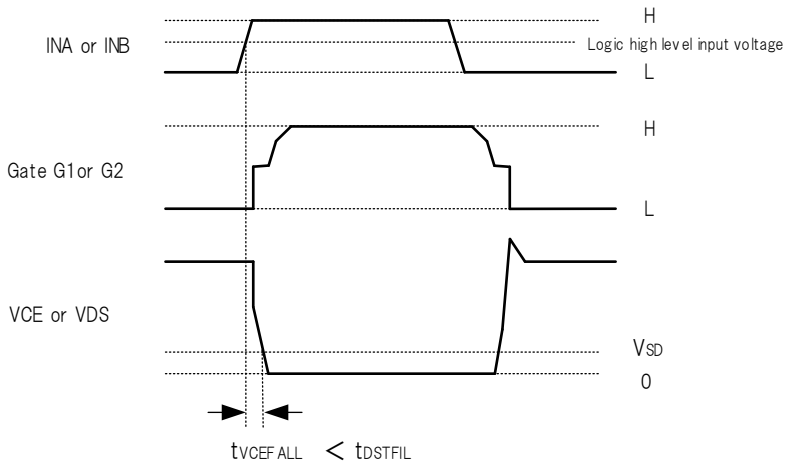


Figure 3.5 Timing chart

4. DC/DC converter protection functions

4.1 Overload protection function

An overload protection function is protection when an output short circuit or overload occurs.
The operation mode is automatic reset operation. Note that an overload decreases gate voltages.

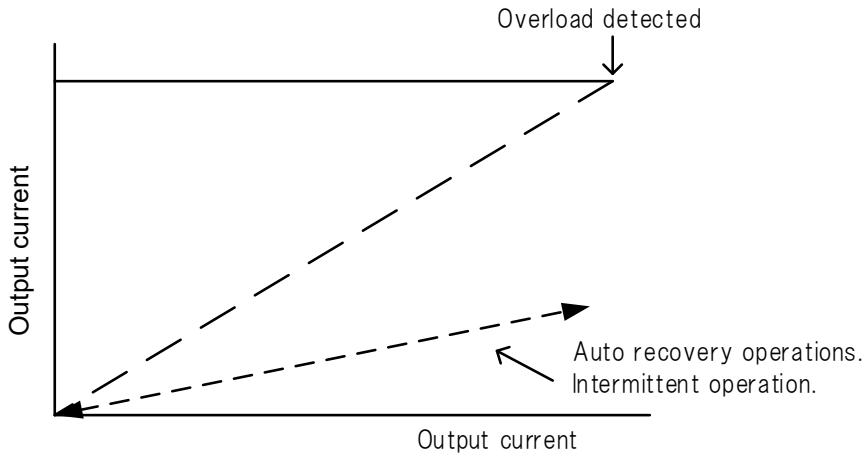


Figure 4.1 Overload protection function

・Automatic recovery operation
In case of output short circuit or overload, intermittent operation continues.
After the output short-circuit or overload is eliminated, operation is automatically restored to normal.

・Between VOx+～E/Sx and E/Sx～VOx-
Overload protection does not work at an output short-circuit or overload between VOx+～E/Sx and E/Sx～VOx-.
Note that VOx+ voltage will rise in case of output short-circuit or overload between E/Sx～VOx-.

4.2 Overheat protection function

This module has an overheat protection function to prevent damage and smoke even if the module overheats for some reason. The operating mode is set for operation stop. Operation is auto restored when the internal temperature of the module becomes normal.

5. Peripheral board design, wiring, and setting for the module

5.1 Gate wiring

Pulse current flows through the part of the VGHx, VGLx and STOx pins indicated by bold lines in the figure below, and so the pattern of that part must be as thick and short as possible.

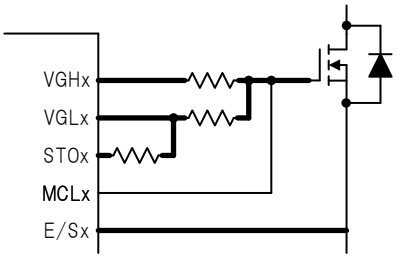


Figure 5.1 Gate wiring

5.2 Areas where components and wiring patterns may be placed

The peripheral areas of the module where components nor patterns may be placed are shown in the figure below. Ensure clearance and creepage with each section according to applicable safety standards.

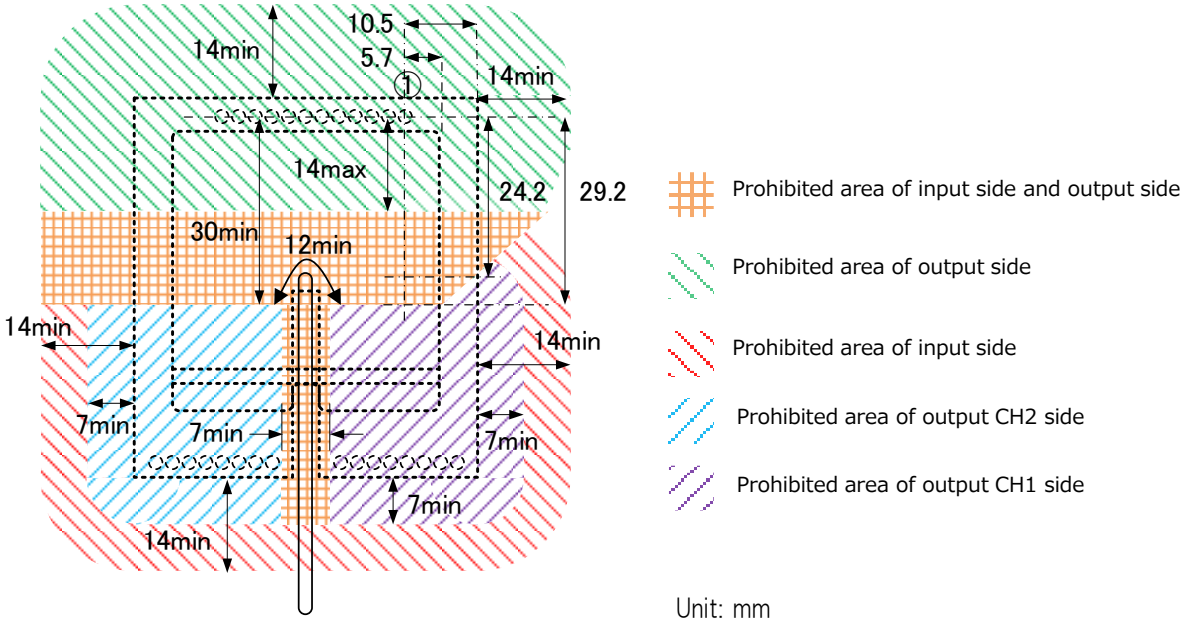
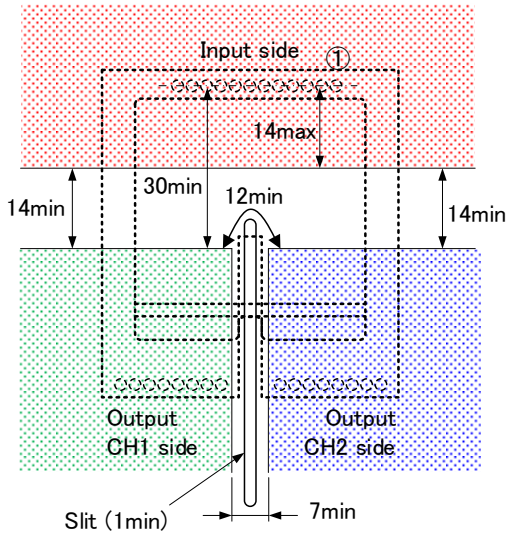
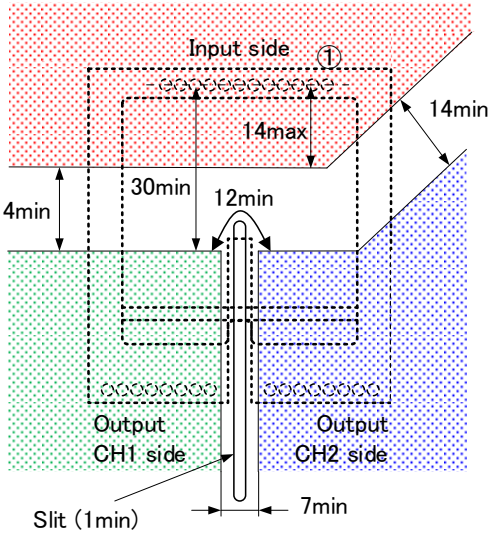


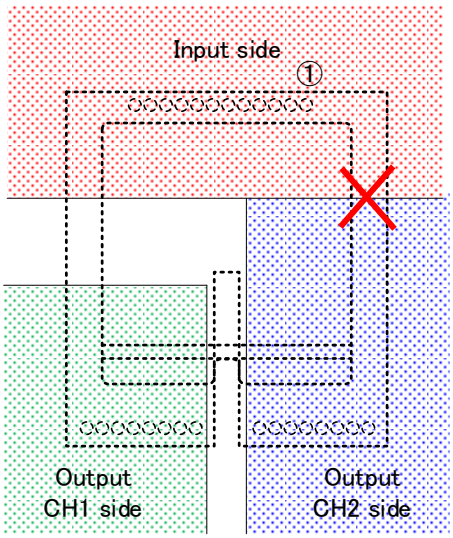
Figure 5.2.1 Prohibited Area of the Application PCB



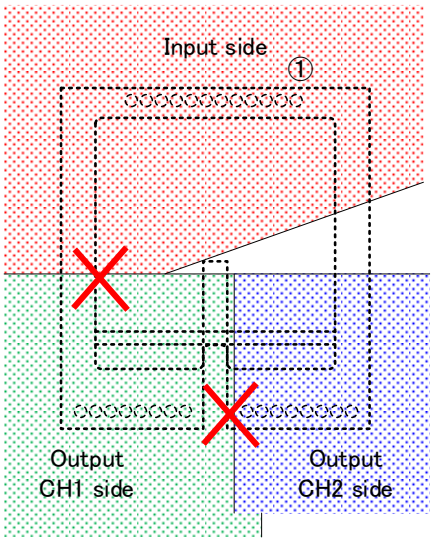
(1) Recommended layout example 1



(2) Recommended layout example 2



(1) NG layout example 1
(Input-Output CH2 distance NG)



(2) NG layout example 2
(Input-Output CH1 and Output CH1-CH2 distance NG)

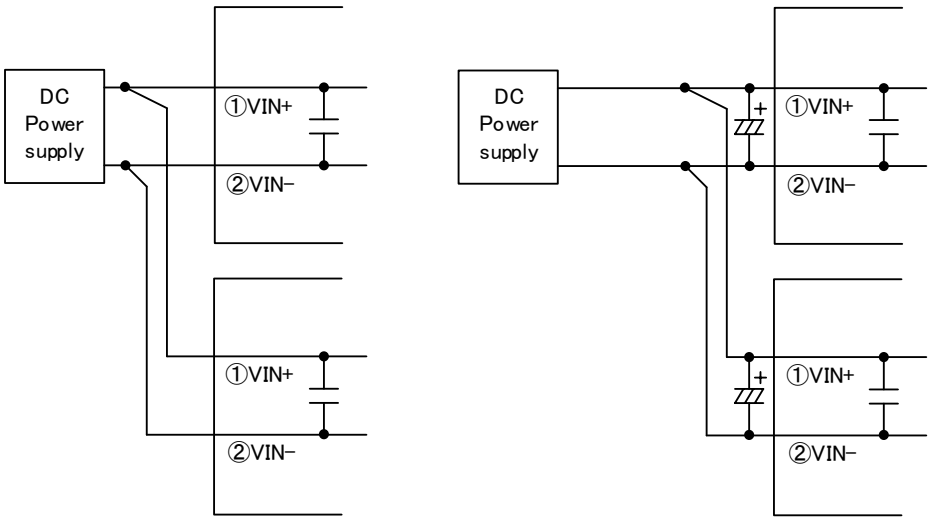
Unit: mm

Figure 5.2.2 Recommended layout example and NG layout example

※Recommended value of Slit width ・・・ Pollution degree1：0.5mm or more / Pollution degree2：1.0mm or more

5.3 Wiring of the DC/DC converter

If multiple modules are driven and there is current flow of between adjacent modules, then wiring should branch from close to the power supply to each module. (Figure 5.3(1))
If it cannot branch from close to the power supply, measures such as adding a capacitor to the branch points should be taken. (Figure 5.3(2))



(1) (2)

Figure 5.3 DC/DC converter power supply wiring

5.4 Use in a strong magnetic field

This product transmits power by magnetic coupling.
Therefore, if it malfunctions during use in a strong magnetic field, the capacitive coupling of GND pins to the frame GND may improve characteristics.

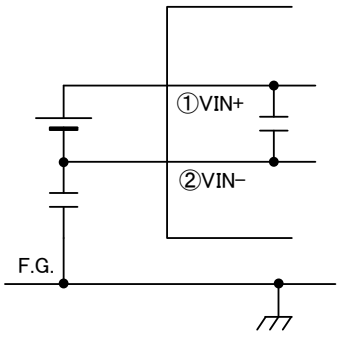


Figure 5.4 Use in a strong magnetic field

5.5 Input signals

The rising and falling time of input signals must be set to 500 ns or less.
In addition, if INA or INB is not used, please be connected to GND instead of open.
(There is a possibility of malfunction due to noise)
Place signal lines as far as possible from the main circuits to avoid noise.
Signal lines must be routed so that the plus and minus sides are capacitively coupled.

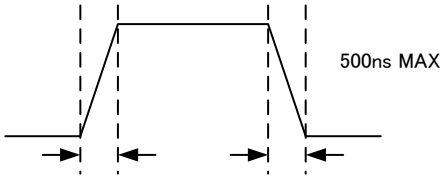


Figure 5.5 Input signal waveform

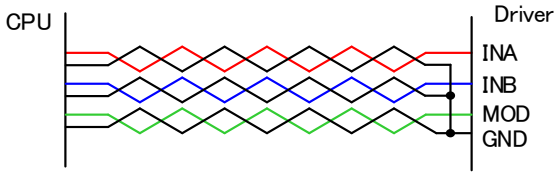


Figure 5.5 (1) Wiring with lead wire

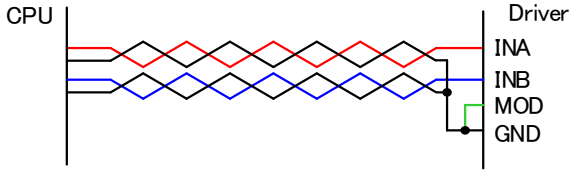


Figure 5.5 (2) Wiring with lead wire (MOD not used)

5.8 Use of a mechanical switch for input for the DC/DC converter

When using a mechanical switch for the input power supply for the DC/DC converter, insert a resistor in the same line to prevent inrush current.

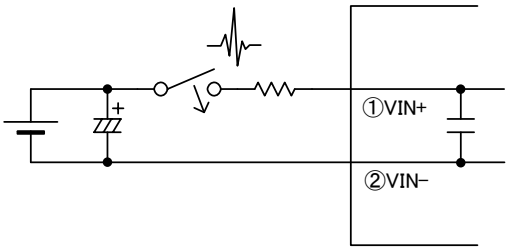
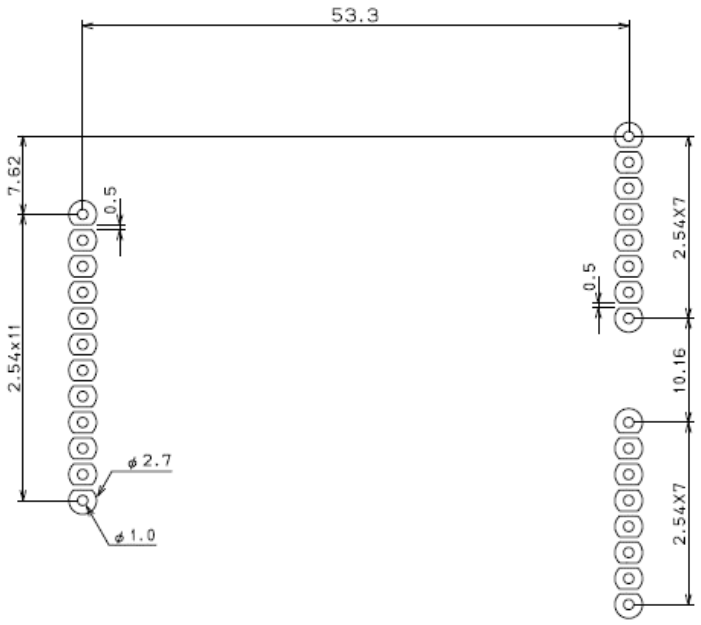


Figure 5.6 Use of a mechanical switch for input

6. Recommended hole diameter, land size, and pin pitch



・Component side view

・Numbers with a circle are pin numbers

In order to ensure resistance to vibration and drop impact, provide all pins with a land, and solder them.

Unit: mm

Figure 6.1 Recommended hole diameter, land size, and pin pitch

7. Recommended soldering conditions (lead-free solder)

(1) Flow soldering: 255 ± 3° C, 5 seconds or less, 110 ± 10° C for preheat end

(2) Soldering iron: 350° C (MAX), 4 seconds or less

8. Temperature derating

For use at an ambient temperature of +60° C or more, reduce output power according to the derating chart of pre data sheet. If heat is generated from a peripheral component, the temperature of the heat should be regarded as the ambient temperature.
If there is no heat-generating component around the module, the temperature at a point that is 20 mm away from the module and 20 mm above the circuit board should be regarded as the ambient temperature.

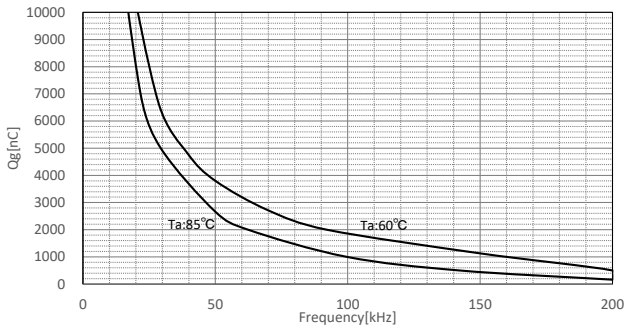


Figure 8.1 Example of derating chart

Point where the ambient temperature is measured if there is a heat-generating component near the module

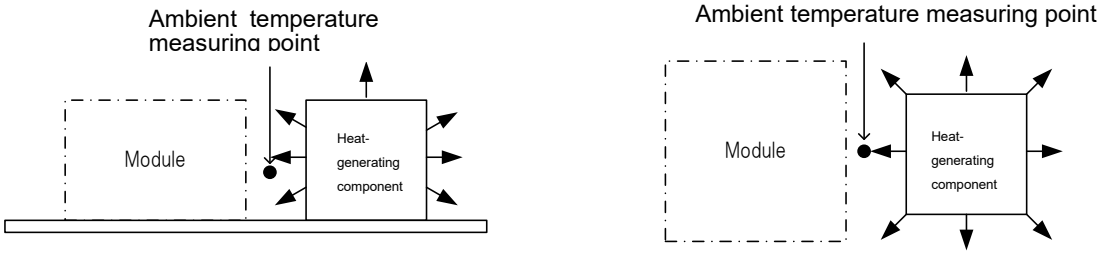


Figure 8.2 Ambient temperature measuring point when there is a heat-generating component near the module

Point where the ambient temperature is measured if there are no effects of heat-generating components

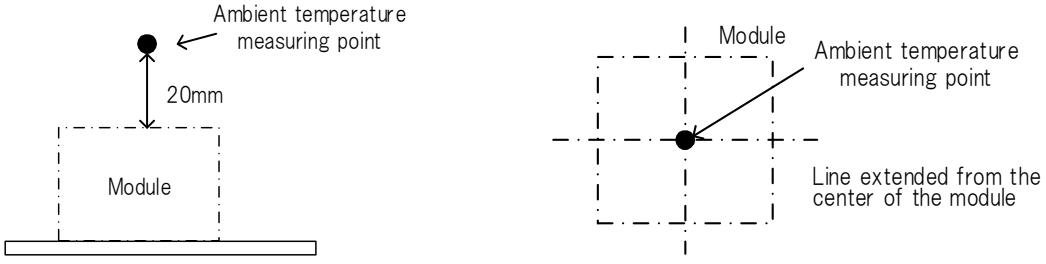


Figure 8.3 Ambient temperature measuring point when there are no effects of heat-generating components

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- Use that involves exposure to direct sunlight, outdoor exposure, or dusty conditions.
- Use in locations where corrosive gases such as salt air, C12, H2S, NH3, SO2, or NO2, are present.
- Use in environments with strong static electricity or electromagnetic radiation.
- Use that involves placing inflammable material next to the product.
- Use of this product either sealed with a resin filling or coated with resin.
- Use of water or a water soluble detergent for flux cleaning.
- Use in locations where condensation is liable to occur.

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