DM Series
Gate Driver Module

Rev.1.1
Aug, 2016

Overview

The Gate driver module (DM 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 DC/DC converter using a quasi-resonant circuit to ensure high efficiency.
- Supporting input voltages of 15 V to 24 V.
- Input-output dielectric withstand voltage: AC2500V (1 second guarantee)
- Input-output insulation distance: 6 mm
- Input-output capacitance of 15 pF typ., highly resistant to common-mode noise.
- Gate driving signal is transmitted using magnetic coupling.
- Very short delays of about 100 ns, providing compatibility with high frequency.
- Resin filling for increased heat dissipation performance.
- DC/DC converter incorporating overcurrent protection and overheating protection.
- Gate drive circuits incorporating a fault signal output 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 SiC-MOSFET)

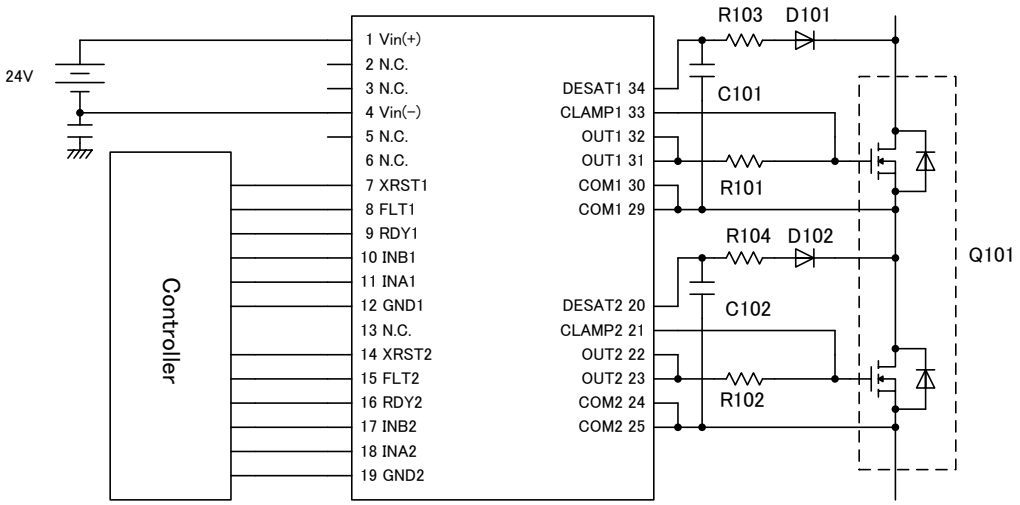


Figure 1.1 Circuit example

1.2 Parts example (For SiC-MOSFET)

Symbol	Description	Part No.	Manufacturer
Q101	SiC MOSFET	BSM120D12P2C005	ROHM
D101,102	Diode	DHM3N20	HITACHI
C101,102	Capacitor	100pF 25V	
R101,102	Resistor	3.9Ω 6W	
R103,104	Resistor	1kΩ	

1.3 Circuit example (For IGBT)

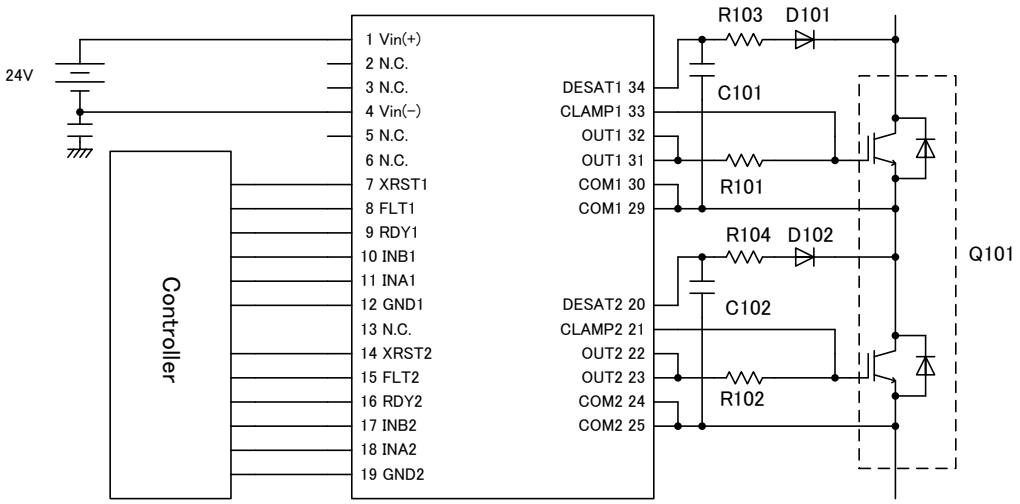


Figure 1.2 Circuit example

1.4 Parts example (For IGBT)

Symbol	Description	Part No.	Manufacturer
Q101	IGBT		
D101,102	Diode	DHM3N20	HITACHI
C101,102	Capacitor	100pF 25V	
R101,102	Resistor	3.9Ω 6W	
R103,104	Resistor	1kΩ	

1.5 Block diagram

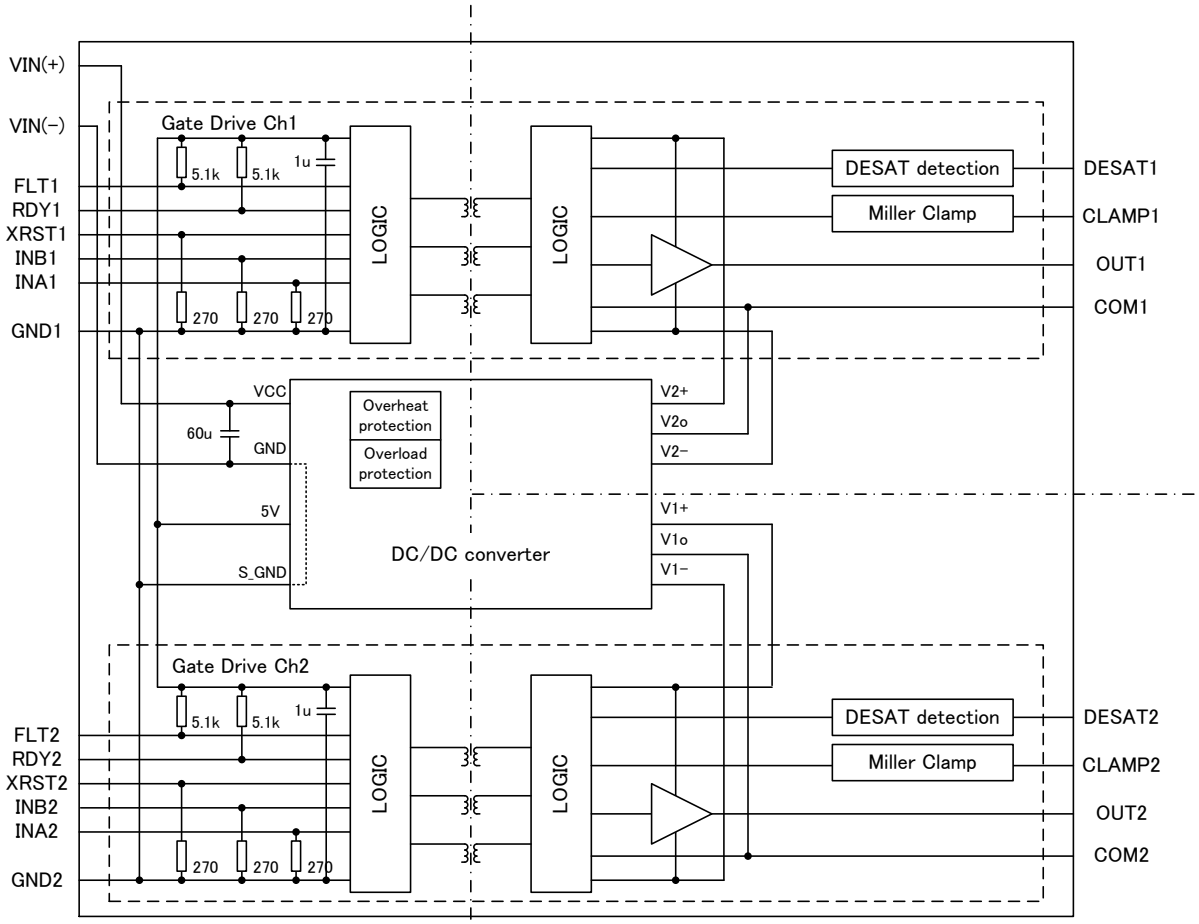


Figure 1.3 Internal block diagram

2. Pin functions and descriptions

2.1 Pin functions

Input side

Pin No.	Name	CH	Explanation of pins
1	Vin(+)	Common	Power supply pin for DC/DC converter(+)
2	N.C.	-	Unused pin *Don't connect with other circuits.
3	N.C.	-	Unused pin *Don't connect with other circuits.
4	Vin(-)	Common	Power supply pin for DC/DC converter(-)
5	N.C.	-	Unused pin
6	N.C.	-	Unused pin
7	XRST1	1	Reset input pin
8	FLT1	1	Fault output pin
9	RDY1	1	Ready output pin
10	INB1	1	Opposite driver's control input pin
11	INA1	1	Control input pin
12	GND1	1	Ground pin for control circuit
13	N.C.	-	Unused pin
14	XRST2	2	Reset input pin
15	FLT2	2	Fault output pin
16	RDY2	2	Ready output pin
17	INB2	2	Opposite driver's control input pin
18	INA2	2	Control input pin
19	GND2	2	Ground pin for control circuit

* Connection to other circuits is impossible

Output side

Pin No.	Name	CH	Explanation of pins
20	DESAT2	2	Desaturation protection pin
21	CLAMP2	2	Miller clamp pin
22	OUT2	2	Gate drive output pin
23	OUT2	2	Gate drive output pin
24	COM2	2	Common pin
25	COM2	2	Common pin
26	NONE	-	None
27	NONE	-	None
28	NONE	-	None
29	COM1	1	Common pin
30	COM1	1	Common pin
31	OUT1	1	Gate drive output pin
32	OUT1	1	Gate drive output pin
33	CLAMP1	1	Miller clamp pin
34	DESAT1	1	Desaturation protection 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) INA, INB, XRST･･･Control input pin, and XRST input pin
The INA, INB and XRST pin is a pin used to determine output logic.
And XRST is in charge of setting back the FLT pin.

XRST	INB	INA	OUT
L	X	X	L
H	H	X	L
H	L	L	L
H	L	H	H

(4) FLT･･･Fault output pin
The FLT pin is an open drain pin used to output a fault signal when desaturation function is activated, and will be cleared at the rising edge of FLT.

Status	FLT
While in normal operation	H
When desaturation function is activated	L

(5) RDY･･･Ready output pin
The RDY pin shows the status of three internal protection features which are 5VDC UVLO, OUT(H) UVLO, and output state feedback (OSFB). The term 'output state feedback' shows whether output internal logic is high or low corresponds to input logic or not.

Status	RDY
While in normal operation	H
5VDC UVLO or OUT(H) UVLO or Output internal logic feedback	L

(6) OUT･･･Output pin
The OUT pin is a pin used to drive the gate of a power device.

(7) CLAMP･･･Miller clamp pin
The CLAMP pin is a pin for preventing increase in gate voltage due to the miller current of the power device connected to OUT pin. Please do not connect if not used. Please connect 10kΩ resistor between CLAMP-COM If the malfunction due to noise is a concern.

(8) DESAT･･･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 COM pin if the desaturation protection is not used. In order to prevent the wrong detection due to noise, the noise mask time $t_{DESATFIL}$ is set.

(9) COM･･･Common pin
The COM pin is a pin to be connected to the emitter / source of the power device.

2.3 Operation truth table

No.	Status	Input							Output			
		V_{5VDC}	V_{OUTH}	DESAT	XRST	INB	INA	CLAMP	OUT	CLAMP	FLT	RDY
1	V_{5VDC} UVLO	UVLO	X	X	X	X	X	H	L	Hi-Z	H	L
2		UVLO	X	X	X	X	X	L	L	L	H	L
3	V_{OUTH} UVLO	○	UVLO	L	X	X	X	H	L	Hi-Z	H	L
4		○	UVLO	L	X	X	X	L	L	L	H	L
5		○	UVLO	H	X	X	X	H	L	Hi-Z	L	L
6		○	UVLO	H	X	X	X	L	L	L	L	L
7	DESAT	○	○	H	X	X	X	H	L	Hi-Z	L	H(∗)
8		○	○	H	X	X	X	L	L	L	L	H(∗)
9	XRST	○	○	L	L	X	X	H	L	Hi-Z	H	H(∗)
10		○	○	L	L	X	X	L	L	L	H	H(∗)
11	Normal operation	○	○	L	H	H	X	H	L	Hi-Z	H	H(∗)
12		○	○	L	H	H	X	L	L	L	H	H(∗)
13		○	○	L	H	L	L	H	L	Hi-Z	H	H(∗)
14		○	○	L	H	L	L	L	L	L	H	H(∗)
15		○	○	L	H	L	H	X	H	Hi-Z	H	H(∗)

○: 5VDC > UVLO, X: Don't care

(∗) If the internal logic of high voltage side doesn't become the expected value, the RDY pin will become "L". And this stage is cleared automatically if the internal logic of high voltage side becomes the expected value.

2.4 Functional description

(1) Gate voltage rise prevention function

If OUT=L and the CLAMP pin voltage < V_{CLPON}, the internal MOSFET of the CLAMP pin turns on.

OUT	CLAMP	Internal MOSFET of the CLAMP pin
L	Less than C_{CLPON}	ON
L	Not less than C_{CLPON}	OFF
H	X	OFF

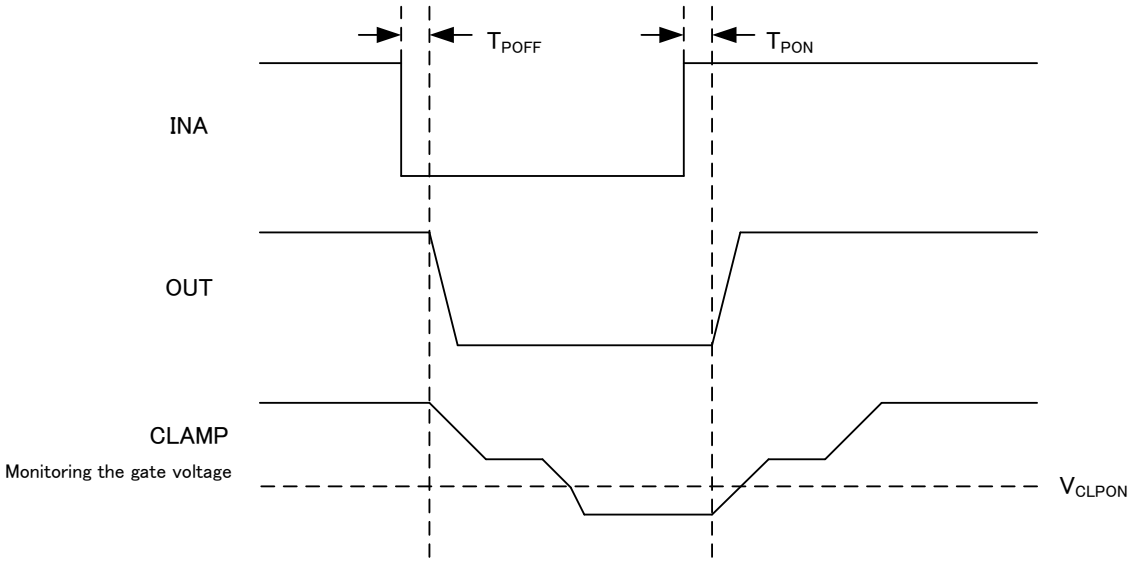


Figure 2.1 Timing chart of Miller clamp function

(2) Undervoltage Lockout (UVLO) function

The control circuit incorporates the undervoltage lockout (UVLO) function both on the 5VDC and the OUT(H) sides. When the 5VDC or the OUT(H) voltage drops to the UVLO ON voltage, the OUT pin and the RDY pin both will output the "L"signal. When the 5VDC or the OUT(H) voltage rises to the UVLO OFF voltage, these pins will be reset. To prevent malfunctions due to noises, mask time $t_{UVLO1MSK}$ and $t_{UVLO2MSK}$ are set on both input and output sides.

(3) Desaturation protection function (DESAT), Fault signal output function

When the DESAT pin voltage exceeds VDESAT, the DESAT function will be activated. When the DESAT function is activated, the OUT pin voltage will be set to the "L" level, and then the FLT pin voltage to the "L" level. When the rising edge is put in the XRST pin, the DESAT function will be released.

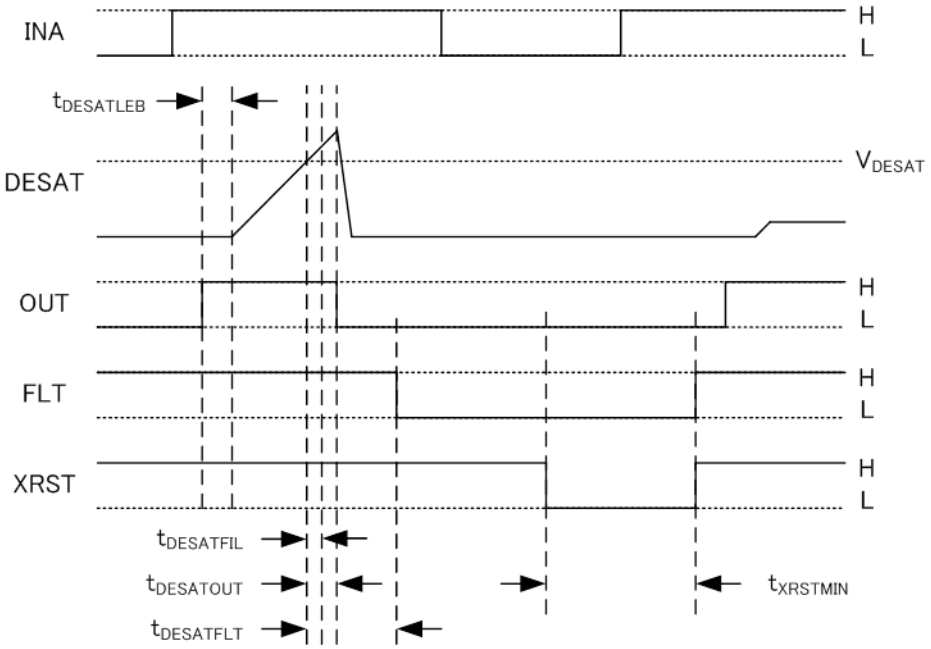


Figure 2.2 DESAT Operation Timing Chart

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 Gate circuits

(1) Selecting gate resistors
When selecting a gate resistor, take into consideration surge voltage, noise, etc., of the elements to be connected. To change the rising and falling time of gate voltages, connect a diode to a path on the OFF side, as shown below. (Figure 3.1)

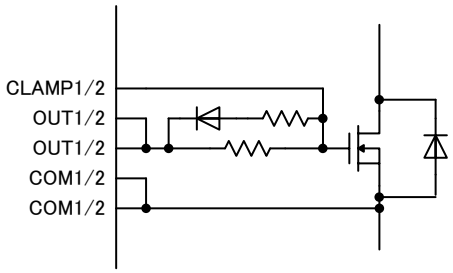


Figure 3.1 Diode connection to an OFF-side path

(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.

3.3 DESAT protection circuit

V_{DS}/V_{CE}, 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.

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

* The detection voltage becomes maximum when $R_{DESAT} = 0\ \Omega$. ($V_{DESAT}-V_F$)
* To further increase the detection voltage, use another high-voltage diode with a low V_F value, or connect a resistor between DESAT and COM. Connecting a resistor between DESAT and COM decreases the current flowing through the high-voltage diode and lowers V_F, thereby increasing the detection voltage.

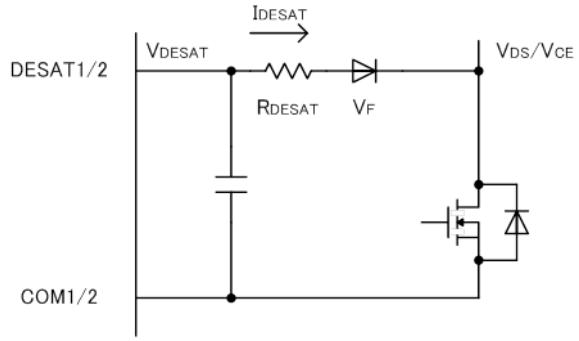


Figure 3.2 DESAT protection circuit

[Design example]
High-voltage diode V_F (I_F=0.5mA) : 2 V
R_{DESAT} resistance : 1000 Ω

Detection voltage V_{DS}/V_{CE} $= V_{DESAT} - (V_F + R_{DESAT} \times I_{DESAT}) = 9V - (2V + 1000\Omega \times 0.5mA)$
$= 6.5V$

[If BSM120D12P2C005/Rohm is used]
Because of drain-source voltage and drain current characteristics, when V_{DS} = 6.5 V, I_D is expressed as follows:
I_D = 200 A (Tj = 125°C)
I_D = 230 A (Tj = 25°C)

4. DC/DC converter protection functions

4.1 Overload protection function

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

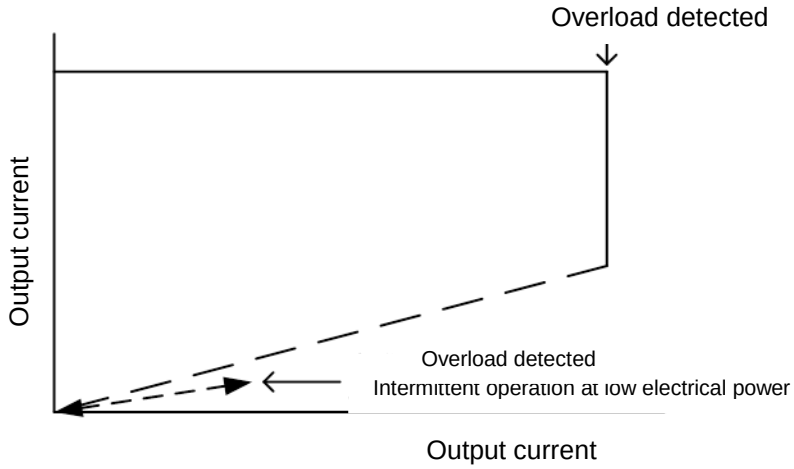


Figure 4.1 Overload protection function

・Automatic recovery operation
Intermittent operation is performed at low voltages with an output short-circuit or overload persisting. After the output short-circuit or overload is eliminated, operation is automatically restored to normal.

4.2 Overheat protection function

The overheat protection function is provided to prevent damage, smoke generation, etc., when the temperature of the module becomes abnormally high for some reason. The operating mode is set for non-latch operation. Operation is 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 OUT and COM pins indicated by bold lines in the figure below, and so the pattern of that part must be as thick and short as possible.

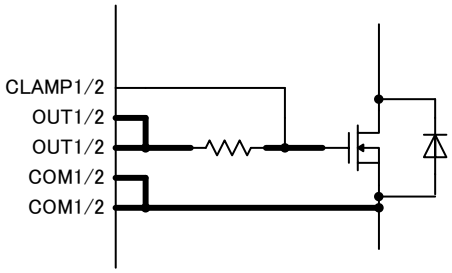
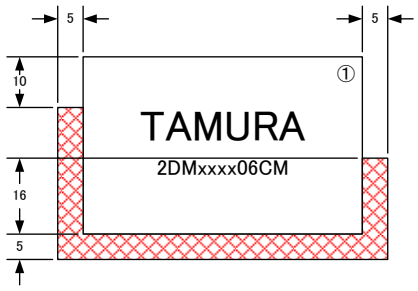


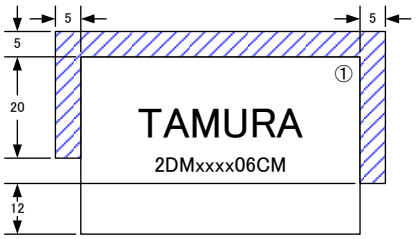
Figure 5.1 Gate wiring

5.2 Areas where neither components nor wiring patterns may be placed

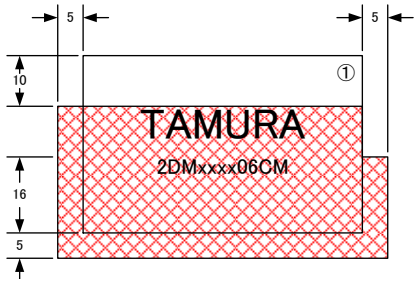
The peripheral areas of the module where neither components nor patterns (on the surface for components) may be placed are shown in the figure below.



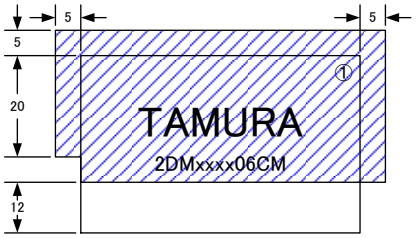
(1) Components of input side prohibited area



(2) Components of output side prohibited area



(3) Pattern of input side prohibited area



(4) Pattern of output side prohibited area

Unit: mm

Figure 5.2 Prohibited areas (patterns and layout)

5.3 Wiring for GND on the input side

Vin (-) of the DC/DC converter and the GND pins of the drive circuit are connected within the module.

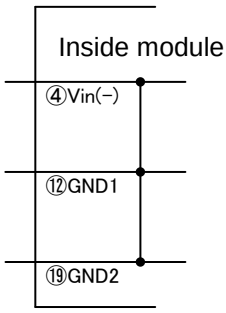
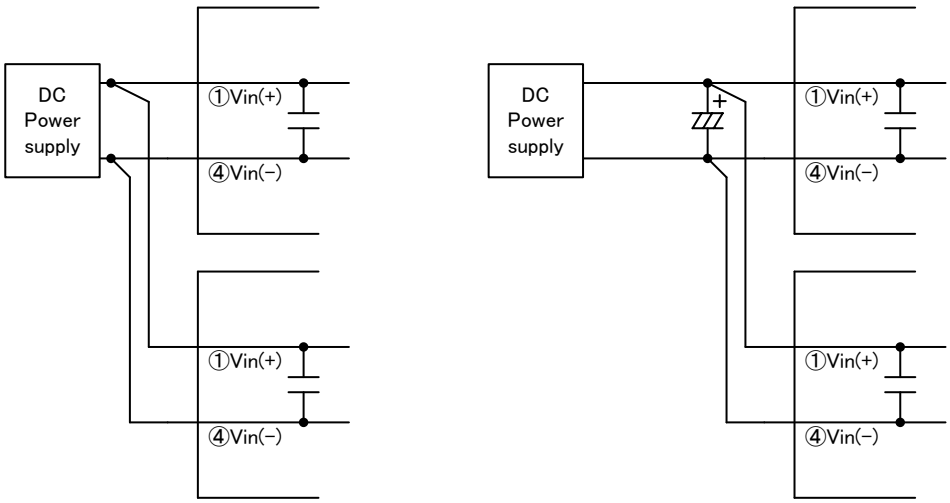


Figure 5.3 Internal GND wiring of the module

5.4 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 5.4(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 5.4(2))



(1) (2)

Figure 5.4 DC/DC converter power supply wiring

5.5 Use in a strong magnetic field

This product transmits signals 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.

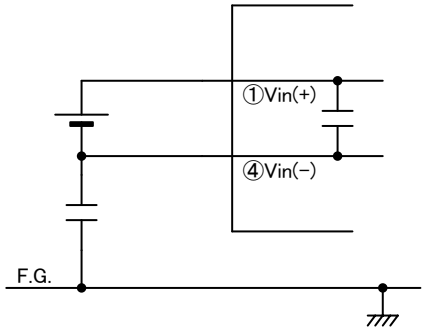


Figure 5.5 Use in a strong magnetic field

5.6 Input signals

The rising and falling time of input signals must be set to 500 ns or less.
In addition, if 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.

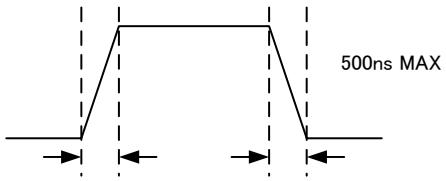


Figure 5.6 Input signal waveform

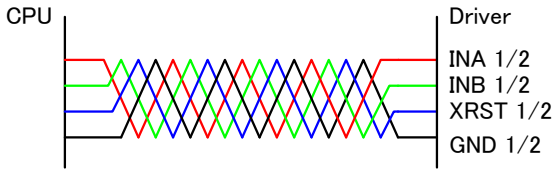


Figure 5.7 (1) Wiring with lead wire

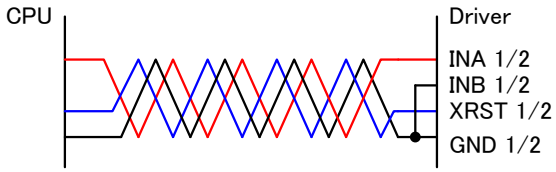


Figure 5.7 (2) Wiring with lead wire (INB not used)

5.7 One-channel driving

This product is designed to optimize the simultaneous driving of two devices with the same gate capacity.
Driving on only one channel may cause unstable operation or may reduce output accuracy.
Also, the drive circuits are independent from each other, and therefore, if the drive circuit on one channel is stopped by the DESAT function, etc., that on the other channel must also be stopped.
If only one device is driven, in order to prevent the reduction in output accuracy, a dummy gate circuit should be made up of a resistor and a capacitor and be switched on and off so that power equivalent to that of the driving side is consumed.

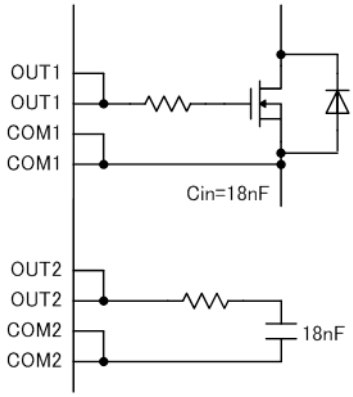


Figure 5.8 Circuit configuration for driving on one channel

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.

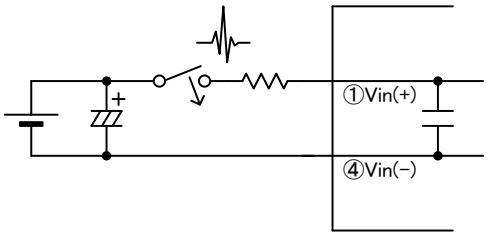
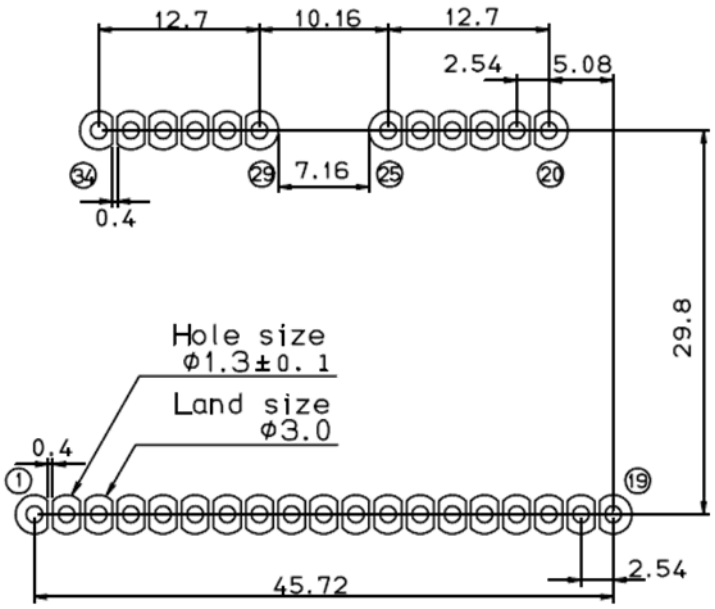


Figure 5.9 Use of a mechanical switch for input

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 +55° C or more, reduce output power according to the input power derating chart below. 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.

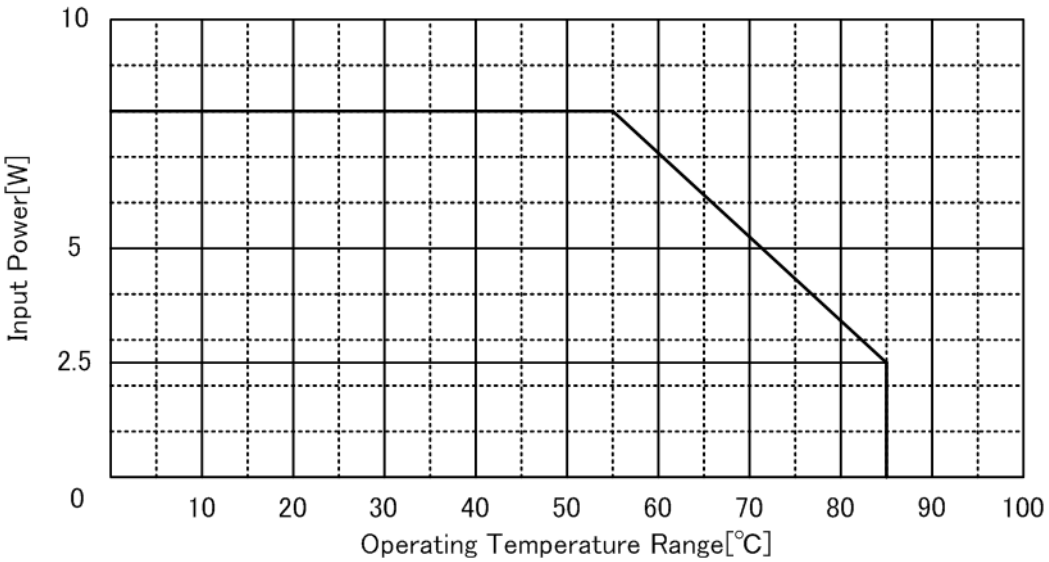


Figure 8.1 Input power derating chart

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

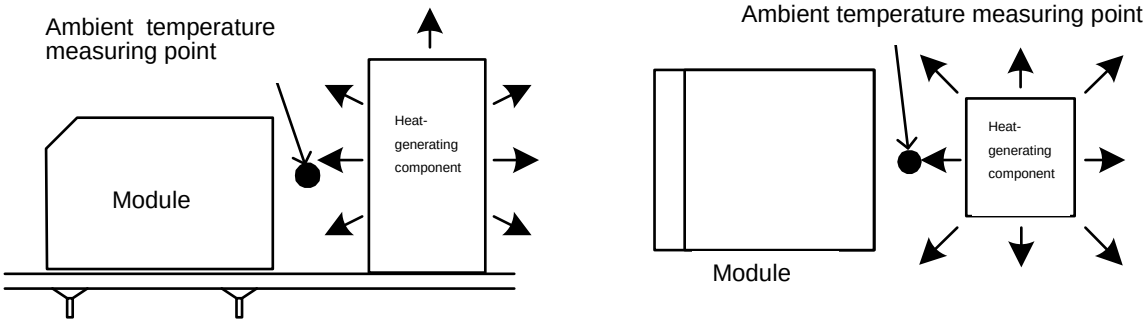


Figure 8.2 Ambient temperature measuring point when there is a heat-generating component near the module

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

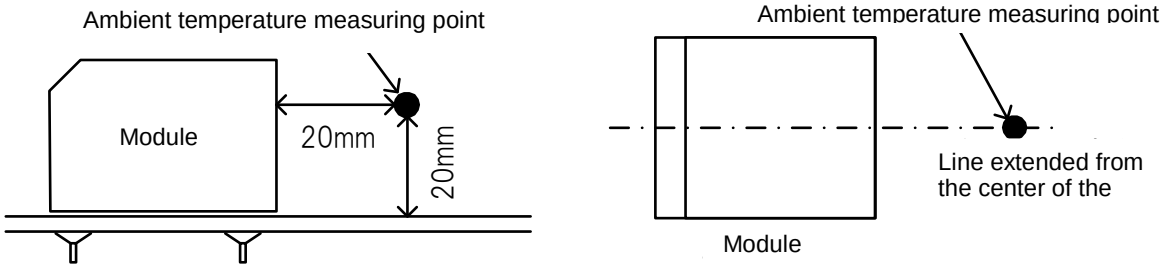


Figure 8.3 Ambient temperature measuring point when there are no effects of heat-generating components

Important Notice

●The content of this information is subject to change without prior notice for the purpose of improvements, etc. Ensure that you are in possession of the most up-to-date information when using this product.

●The operation examples and circuit examples shown in this document are for reference purposes only, and TAMURA Corporation disclaims all responsibility for any violations of industrial property rights, Intellectual property rights and any other rights owned by TAMURA Corporation or third parties that these may entail.

●The circuit examples and part constants listed in this document are provided as reference for the verification of characteristics. You are to perform design, verification, and judgment at your own responsibility, taking into account the various conditions.

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●This product is intended for use in consumer electronics (electric home appliances, business equipment, Information equipment, communication terminal equipment, measuring devices, and so on.) If considering use of this product in equipment or devices that require high reliability (medical devices, transportation equipment, traffic signal control equipment, fire and crime prevention equipment, aeronautics and space devices, nuclear power control, fuel control, in-vehicle equipment, safety devices, and so on), please consult a TAMURA sales representative in advance. Do not use this product for such applications without written permission from TAMURA Corporation.

●This product is intended for use in environments where consumer electronics are commonly used. It is not designed for use in special environments such as listed below, and if such use is considered, you are to perform thorough safety and reliability checks at your own responsibility.

- Use in liquids such as water, oil, chemical solutions, or organic solvents, and use in locations
- Where the product will be exposed to such liquids.
- 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.

●This product is not designed to resist radiation.

●This product is not designed to be connected in series or parallel. Do not operate this product in a series, parallel, or N+1 redundant configuration.

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