Gate Driver Unit 4DUC51016xFA2 for 3-Level IGBT

■Overview

4DUC51016xFA2 is a quad channel gate driver designed for Fuji Electric's IGBT power module 4MBI900VB-120RA-50 .
This gate driver unit contains a built-in isolated DC/DC converter and gate drive circuit.
It is ready to use by mounting it on the IGBT power module.

■Features

- ·Ideal for drive of 3-Level inverter
- ·Ideal for drive of IGBT Power module 4MBI900VB-120RA-50 (Fuji Electric)
- ·Gate voltage : +15V/-10V
- ·Gate resistor (T1,T4) : +3.9Ω/-1.0Ω(TYP)
- ·Gate resistor (T2,T3) : +2.7Ω/-15Ω(TYP)
- ·Short circuit detection voltage : 10V(TYP)
- ·ALL-IN-ONE (Built-in isolated DC / DC converter and gate drive circuit)
- ·Low parasitic capacitance (12pF(TYP)) ; highly resistant to common-mode noise.
- ·Fast response : About 130nsec(typ)
- ·The isolation for primary-secondary signal used fast response isolator.
- ·Dielectric withstand voltage : AC5000V
- ·Insulation distance (clearance / creepage) : 14mm/14mm
- ·DC/DC converter input voltage : 13～28V
- ·Power supply for gate driver input voltage : 13～28V
- ·Signal input voltage : 3.3V～15V or 15V
- ·Overload protection (DC/DC converter)
- ·Overheat protection (DC/DC converter)
- ·Desaturation protection (Gate drive circuit / T1, T4)
- ·Soft turn-off function (Gate drive circuit / T1, T4)
- ·Fault signal output function (Gate drive circuit)
- ·Under-voltage lockout(UVLO) (Gate drive circuit)
- ·Safety standards:UL508(file no.E243511) (DC/DC converter only)
- ·UL1741, UL508, IEC62109-1, EN50178 compliant (Reinforced isolation according to IEC 60664-1)

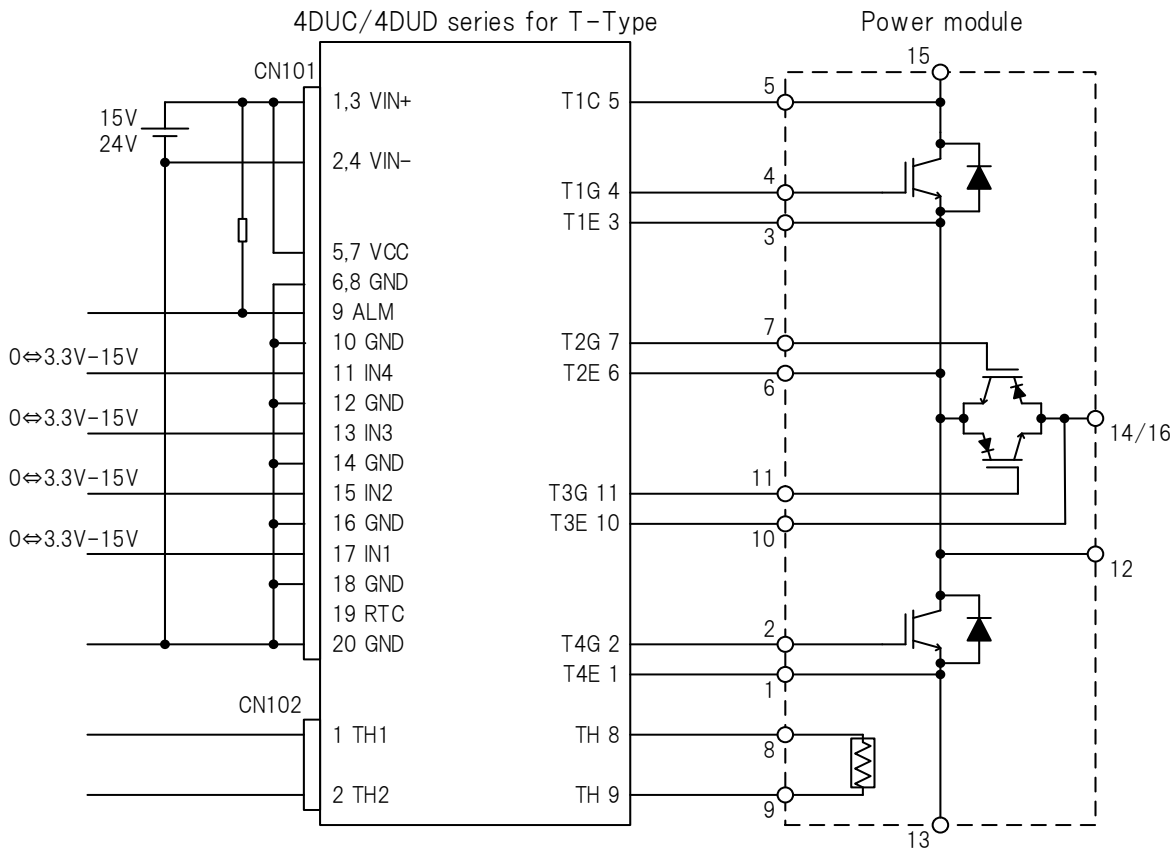
■Application

Industrial inverter, power conditioner, etc …

■Module information

Part number	Signal input voltage	Active clamp	Status
4DUC51016CFA2	3.3 to 15V	None	Active
4DUC51016DFA2	15V	None	Sample

■Circuit Image



■Pin Connection

CN101 : RA-H201SD (JST), 71922-120LF (FCI) or PS-20PE-D4LT2-M1E (JAE)

Pin No.	Name	Function	Pin No.	Name	Function
1	VIN(+)	Power supply for DC/DC converter(+)	2	VIN(-)	Power supply for DC/DC converter(-)
3	VIN(+)	Power supply for DC/DC converter(+)	4	VIN(-)	Power supply for DC/DC converter(-)
5	VCC	Power supply for drive circuit	6	GND	Ground for drive circuit
7	VCC	Power supply for drive circuit	8	GND	Ground for drive circuit
9	ALM	Alarm signal output	10	GND	Ground for drive circuit
11	IN4	Control input 4	12	GND	Ground for drive circuit
13	IN3	Control input 3	14	GND	Ground for drive circuit
15	IN2	Control input 2	16	GND	Ground for drive circuit
17	IN1	Control input 1	18	GND	Ground for drive circuit
19	RTC	Recovery time of protection circuit control	20	GND	Ground for drive circuit

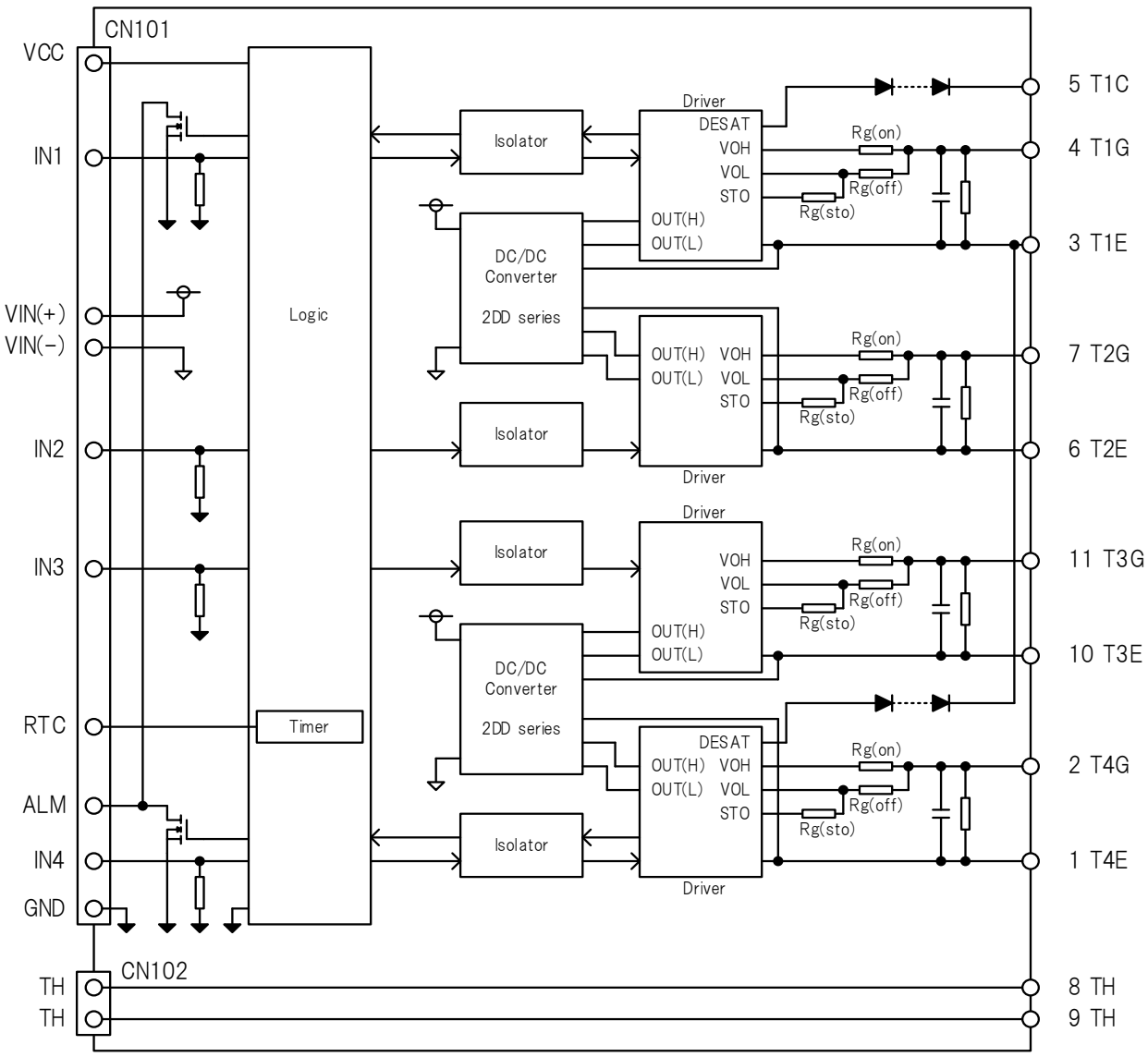
※Recommend receptacle : RA-S201T (JST), 71600-020LF(FCI) or PS-20SM-D4P1-1*(JAE)

CN102 : S2B-XH-A For thermistor ※Recommend receptacle : XHP-2 (JST)

Connection on the power module

Pin No.	Name	Function	Pin No.	Name	Function
1	T4E	T4 Emitter connection	6	T2E	T2 Emitter connection
2	T4G	T4 Gate connection	7	T2G	T2 Gate connection
3	T1E	T1 Emitter connection	8	TH	For thermistor
4	T1G	T1 Gate connection	9	TH	For thermistor
5	T1C	T1 Collector connection	10	T3E	T3 Emitter connection
			11	T3G	T3 Gate connection

■Internal Block Diagram



■I/O Condition Table

No.	Status	Input								Output				
		OUT(H)	V_{CC}	T1C	T4C	IN1	IN2	IN3	IN4	ALM	T1G	T2G	T3G	T4G
1	V_{OUT}UVLO	UVLO	○	X	X	X	X	X	X	L	L	L	L	L
2	G-E short	○	○	X	X	X	X	X	X	Hi-Z	SD	SD	SD	SD
3	VccUVLO	○	UVLO	X	X	X	X	X	X	Hi-Z	L	L	L	L
4	Normal operation	○	○	L	L	L	X	X	X	Hi-Z	L	X	X	X
5		○	○	L	L	H	X	X	X	Hi-Z	H	X	X	X
6		○	○	L	L	X	L	X	X	Hi-Z	X	L	X	X
7		○	○	L	L	X	H	X	X	Hi-Z	X	H	X	X
8		○	○	L	L	X	X	L	X	Hi-Z	X	X	L	X
9		○	○	L	L	X	X	H	X	Hi-Z	X	X	H	X
10		○	○	L	L	X	X	X	L	Hi-Z	X	X	X	L
11		○	○	L	L	X	X	X	H	Hi-Z	X	X	X	H
12	Short circuit detection (T1)	○	○	Hi-Z	L	L	X	X	X	Hi-Z	L	X	X	X
13		○	○	Hi-Z	L	H	X	X	X	L	L	X	X	X
14	Short circuit detection (T4)	○	○	L	Hi-Z	X	X	X	L	Hi-Z	X	X	X	L
15		○	○	L	Hi-Z	X	X	X	H	L	X	X	X	L

G-E short : Gate-Emitter short

○ : OUT(H) UVLO > UVLO, X : Don't care

SD: Shut down (Gate-Emitter short)

■Absolute Maximum Ratings

Item		Symbol	Min	Max	Unit	Conditions・Note
Input voltage for DC/DC converter		V_{IN}	-0.3	28	Vdc	Between VIN(+) to VIN(-)
Input voltage for Gate driver		V_{CC}	-0.3	28	Vdc	Between VCC to GND
Input-side signal voltage		V_{SG}	-0.3	V_{CC}+0.3 or 18 *	V	IN1, IN2, IN3, IN4 *Whichever is less
		V_{RTC}	-0.3	5	V	RTC
Maximum gate current		I_{GPEAK}	-	43	A	Excluding gate resistor
Switching frequency	Average	F_{SW}	-	7.5	kHz	Test load (T1,T4) : 0.8Ω/340nF Test load (T2,T3) : 2.8Ω/162nF
	Peak		-	15	kHz	
Short circuit detection pin voltage		V_{SD}	0	1200	V	
Alarm signal output pin maximum voltage		V_{ALM}	-0.3	V_{CC}+0.3 or 28 *	V	ALM1,2 *Whichever is less
Input-side signal maximum current		I_{ALM}	-	5	mA	ALM
Operating temperature range	V_{IN}=13.5-18V	T_{OP}	-40	85	℃	See the derating curve
	V_{IN}=18-26.4V	T_{OP}	-40	75	℃	
Operating humidity		RH_{OP}	20	95	%RH	No condensation
Storage temperature range		T_{STG}	-40	90	℃	
Storage humidity		RH_{STG}	5	95	%RH	No condensation

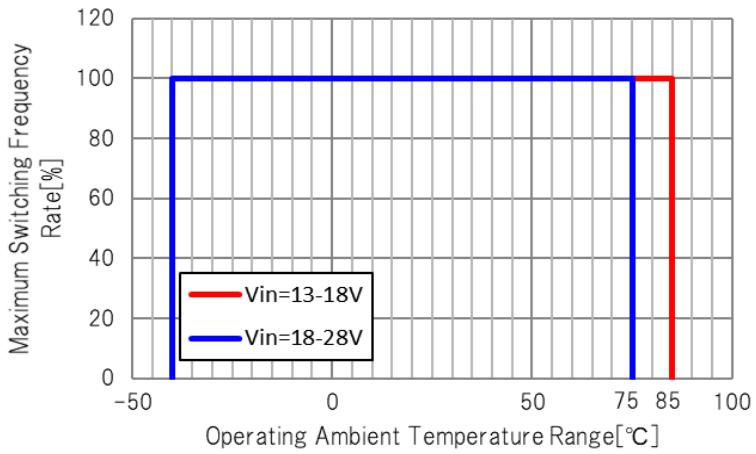
■Recommended Operating Conditions

Item		Symbol	Min	Max	Unit	Conditions・Note
Input voltage range for DC/DC converter		V_{IN}	13.5	26.4	Vdc	
Input voltage range for gate driver		V_{CC}	13.5	26.4	Vdc	
Driver circuit number		N	-	4	-	
Maximum gate charge	T1, T4	Q_G	-	8500	nC	
	T2, T3		-	3900	nC	
4DUx51016Cxxx						
Logic high level input voltage		V_{SGH}	3.3	Vcc+0.3 or 16 *	V	IN1, IN2, IN3, IN4 *Whichever is less
Logic low level input voltage		V_{SGL}	-0.3	0.5	V	IN1, IN2, IN3, IN4
Source current of control signal		I_{SG}	3.2	-	mA	IN1, IN2, IN3, IN4 VSG=15V
4DUx51016Dxxx						
Logic high level input voltage		V_{SGH}	13	Vcc+0.3 or 16 *	V	IN1, IN2, IN3, IN4 *Whichever is less
Logic low level input voltage		V_{SGL}	-0.3	0.5	V	IN1, IN2, IN3, IN4
Source current of control signal		I_{SG}	3.3	-	mA	IN1, IN2, IN3, IN4 VSG=15V

■Ambient Temperature Derating Curve

Reduce the switching frequency according to the following temperature derating table.

Switching Frequency 100% = 7.5kHz



■Electrical Specification (Vin=Vcc=15V.Ta=25℃, Unless otherwise specified)

Item		Symbol	Min	Typ	Max	Unit	Conditions・Note
DC/DC converter							
Start-up voltage		V_{START}	-	11.5	12.5	V	
Input current		I_{IN}	-	0.5	-	A	Fsw=7.5kHz, Test load(T1,T4) : 0.8Ω/340nF Fsw=7.5kHz, Test load(T2,T3) : 2.8Ω/162nF
Standby power		P_{STBY}	-	2.5	-	W	No load
Logic inputs for 4DUx51016Cxxx							
Logic high level input voltage		V_{SGH}	-	2.1	2.3	V	IN1, IN2, IN3, IN4 / Guaranteed by design
Logic low level input voltage		V_{SGL}	1	1.2	-	V	IN1, IN2, IN3, IN4 / Guaranteed by design
Logic pull-down resistance		R_{SGD}	-	4700	-	Ω	IN1, IN2, IN3, IN4
Logic inputs for 4DUx51016Dxxx							
Logic high level input voltage		V_{SGH}	-	10.4	11.4	V	IN1, IN2, IN3, IN4 / Guaranteed by design
Logic low level input voltage		V_{SGL}	4.9	5.9	-	V	IN1, IN2, IN3, IN4 / Guaranteed by design
Logic pull-down resistance		R_{SGD}	-	4500	-	Ω	IN1, IN2, IN3, IN4
Gate driver output							
Output pin voltage(High)		V_{OUTH}	14	15	16	V	No load
Output pin voltage(Low)		V_{OUTL}	-11	-10	-9	V	No load
Gate resistor	T1, T4	Rg(ON)	-	3.9	-	Ω	
		Rg(OFF)	-	1.0	-		
	T2, T3	Rg(ON)	-	2.7	-	Ω	
		Rg(OFF)	-	15	-		
Auxiliary gate capacitor	T1, T4	Cge	-	OPEN	-	nF	
	T2, T3	Cge	-	OPEN	-	nF	
Delay time	Turn ON time	t_{PON}	-	130	-	ns	
	Turn OFF time	t_{POFF}	-	130	-	ns	

■Protection

Item	Symbol	Min	Typ	Max	Unit	Conditions・Note
DC/DC converter						
Overload protection	-	10.5	-	-	W	Auto recovery
Overheat protection	-	120	-	150	℃	Auto recovery, Internal temperature
Gate driver						
VCC UVLO OFF voltage	$V_{UVLOVCCH}$	-	9.1	-	V	
VCC UVLO ON voltage	$V_{UVLOVCCL}$	-	7.3	-	V	
Output voltage(H) UVLO OFF voltage	$V_{UVLOOHH}$	13.2	13.5	13.8	V	Guaranteed by design
Output voltage(H) UVLO ON voltage	$V_{UVLOOHL}$	12.2	12.5	12.8	V	Guaranteed by design
Short circuit detection voltage	V_{SD}	-	10	-	V	
Short circuit detection filter time	$t_{SHORTFIL}$	-	4.5	-	us	Collector open
Alarm signal output L voltage	V_{ALML}	-	-	0.5	V	I_{ALM}=5mA
Alarm signal output time	t_{ALM}	-	0.2	-	us	
Restart time	$t_{RESTART}$	-	110	-	ms	
Soft turn-off resistance	R_{STO}	-	15	-	Ω	
Soft turn-off duration	t_{STO}	-	4	-	us	

■Insulation

Item	Specification	Conditions・Note
Between Input-Output		
Dielectric withstand voltage	AC5000V	1min, Cutoff 2mA
Insulation resistance	100MΩ or more	DC500V
Partial discharge extinction voltage	1768Vpeak or more	According to EN50178/IEC 60270
Common-mode transient immunity (CMTI)	70kV/us	
Minimum clearance distances	14mm	
Minimum creepage distances	14mm	
Between Output-Output		
Minimum clearance distances	8mm	
Minimum creepage distances	8mm	
Between Thermistor-Output		
Minimum clearance distances	8mm	
Minimum creepage distances	8mm	

■Pin Function

・VIN(+), VIN(−) (Power supply pin for DC/DC converter)

・VCC(Power supply pin for drive circuit)

・GND(Ground pin for drive circuit)

・IN1, IN2, IN3, IN4(Control input pin)

The IN1, IN2, IN3 and IN4 pin is a pin used to determine output logic.

IN1	IN2	IN3	IN4	T1G	T2G	T3G	T4G
L	X	X	X	L	X	X	X
H	X	X	X	H	X	X	X
X	L	X	X	X	L	X	X
X	H	X	X	X	H	X	X
X	X	L	X	X	X	L	X
X	X	H	X	X	X	H	X
X	X	X	L	X	X	X	L
X	X	X	H	X	X	X	H

・RTC(Recovery time of protection circuit control pin)

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

・ALM(Alarm signal output pin)

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

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

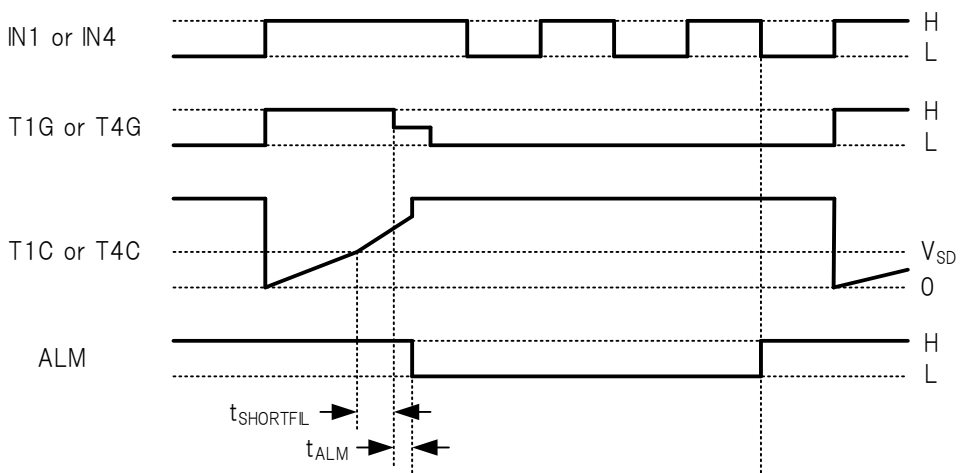
■Description

1. Undervoltage Lockout (UVLO) function

The control circuit incorporates the undervoltage lockout (UVLO) function both on the VCC and the OUT(H) sides.
When the OUT(H) voltage drops to the UVLO ON voltage, the Output pin and the ALM pin both will output the “L” signal.
When the VCC voltage drops to the UVLO ON voltage, the Output pin will output the “L” signal.
When the VCC or the OUT(H) voltage rises to the UVLO OFF voltage, these pins will be reset.

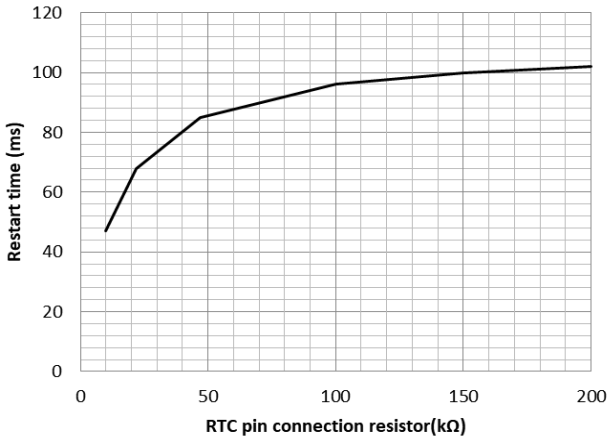
2. Short circuit protection function, Soft turn-off function (T1, T4)

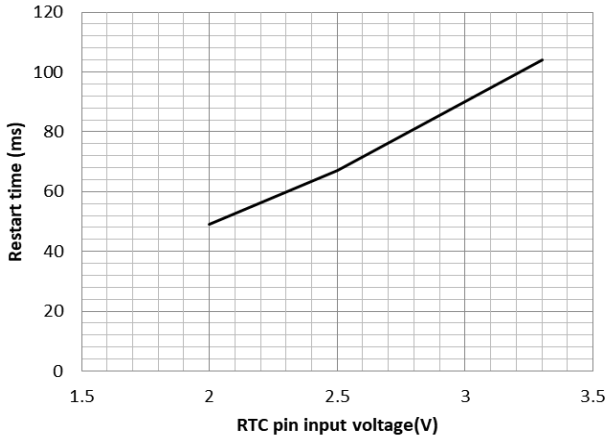
When the collector pin voltage exceeds V_{SD}, the short circuit protection function will be activated.
When the short circuit protection function is activated, the OUT pin voltage will be set to the “L” level,
and then the ALM pin voltage to the “L” level.
Also, soft turn-off function works to reduce collector 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.



Timing chart of short circuit protection function

The restart time can be adjusted within the following range by the resistance or voltage connected to the RTC pin.





■Description

3. Active clamp gate function

None

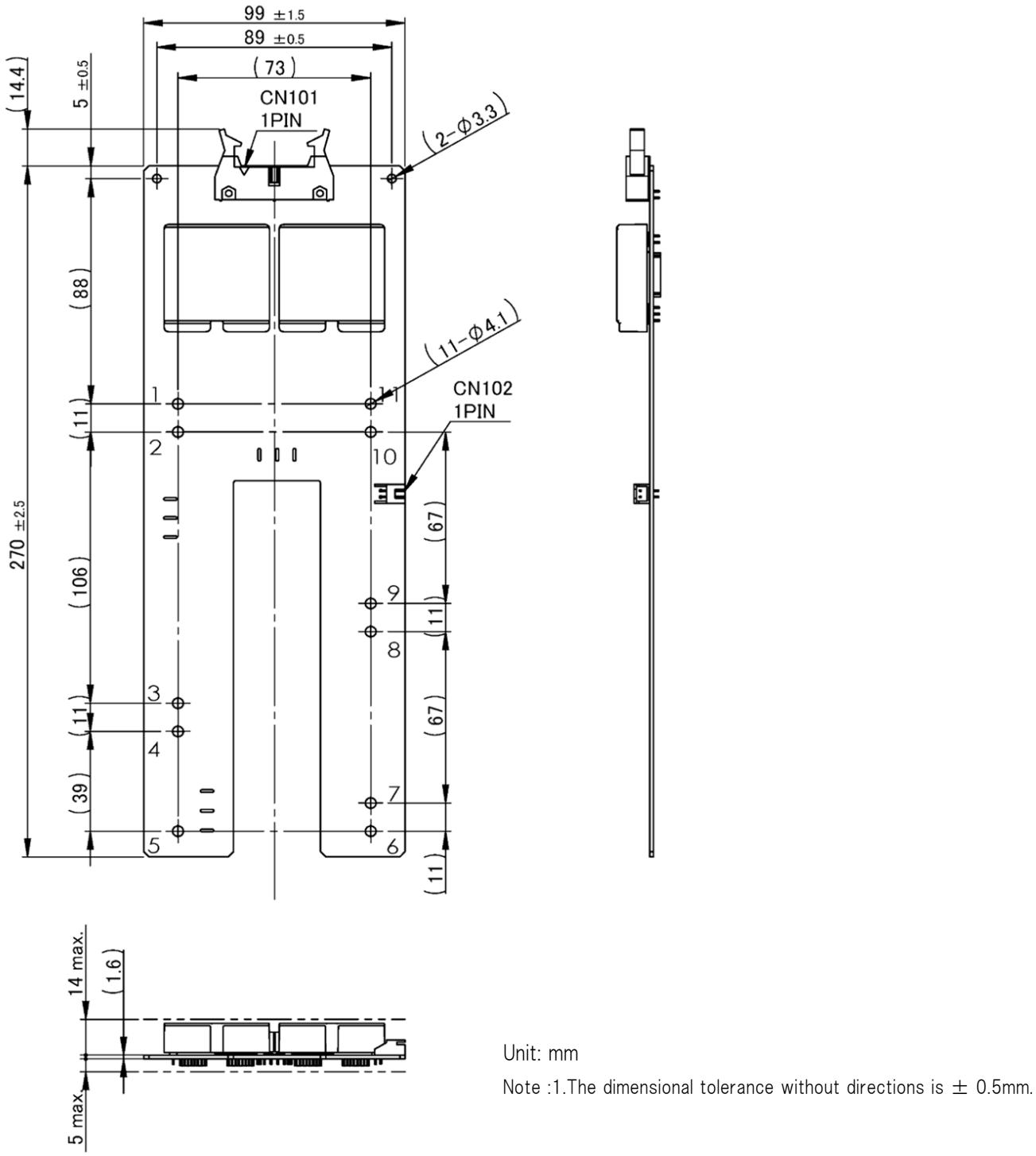
■Reliability

Item	Test condition and acceptance criterion
Exposure in high temperature	IEC60068-2-2:2007: Test: Bb, 90℃, 240H, ※
Exposure in low temperature	IEC60068-2-1:2007: Test: Ab, -40℃, 240H, ※
Exposure in high temperature and high humidity	IEC60068-2-78:2012-10, 60℃, 90～95%RH, 240H, ※
Thermal shock	IEC60068-2-14:2009-01: Test: Na, -40℃/30min to 100℃/30min, 500cycles, ※
Low temperature operation	IEC60068-2-1:2007: Test: Ae, Input voltage: DC24V, Output current: Rated Load -40℃, 240H, ※
High temperature operation	IEC60068-2-2:2007: Test: Be, Input voltage: DC24V, Output current: Rated Load 85℃, 240H, ※
high temperature and high humidity operation	IEC60068-2-78:2012-10, Input voltage: DC24V, Output current: Rated Load 85℃, 85%RH, 240H, ※
Vibration	IEC 60068-2-6:2007-12, Frequency range: 10 to 55Hz, Sweep rate: 1.0oct/min, Displacement amplitude: ±0.75mm, Test duration: 120min, Axis: X,Y and Z, ※
	IEC 60068-2-6:2007-12, Frequency range: 5 to 200Hz, Sweep rate: 1.0oct/min, Cross-over frequency: 8.4Hz, , Displacement amplitude(5 to 8,4Hz): ±3.5mm, Acceleration amplitude(8.4 to 200Hz):1G, Test duration: 20sweeps, Axis: X, Y and Z, ※
Impact	IEC 60068-2-27:2008-02, Pulse shape: Half-sine, Corresponding duration: 11ms, Peak acceleration: 50G, Number of shocks:3, Axis: ±X, Y and Z, ※
	IEC 60068-2-27:2008-02, Pulse shape: Half-sine, Corresponding duration: 6ms, Peak acceleration: 15G, Number of shocks:100, Axis: ±X, Y and Z, ※

※After each test, exposure at room temperature and humidity condition for 24 hours.

There shall be no abnormality on the electrical specification and appearance.

■Outline Dimensional Drawing



Unit: mm

Note :1.The dimensional tolerance without directions is ± 0.5mm.

■Product Weight

145g(TYP)

■Storage Conditions

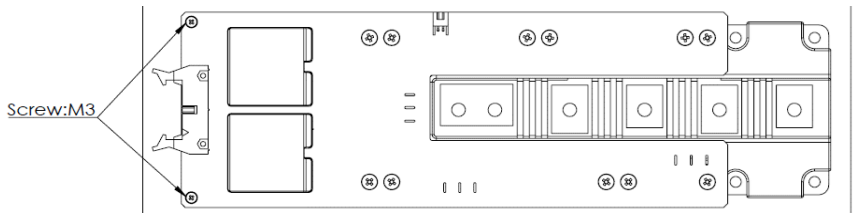
Item	Min	Max	Unit	Conditions・Note
Storage temperature	-25	60	℃	A packing state

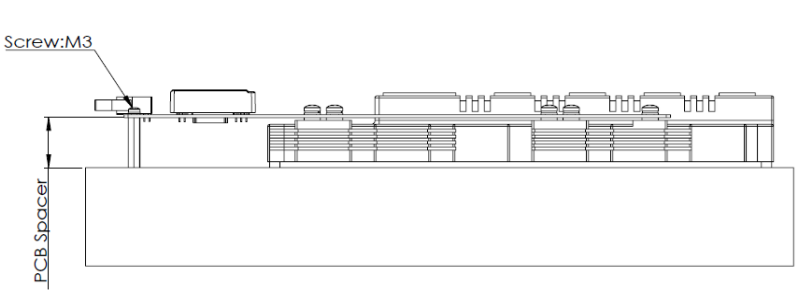
■Usage Cautions

● Always mount fuse on the plus side of input for ensuring safety because the fuse is not built-in the product.
Please select the fuse considering conditions such as steady current, inrush current, and ambient temperature.
When using a fuse having large rated current or high capacity input electrolytic condenser, by combining
another converter and input line and input electrolytic condenser, fuse may not blow off in the case of abnormality.
Do not combine high voltage line and fuse.

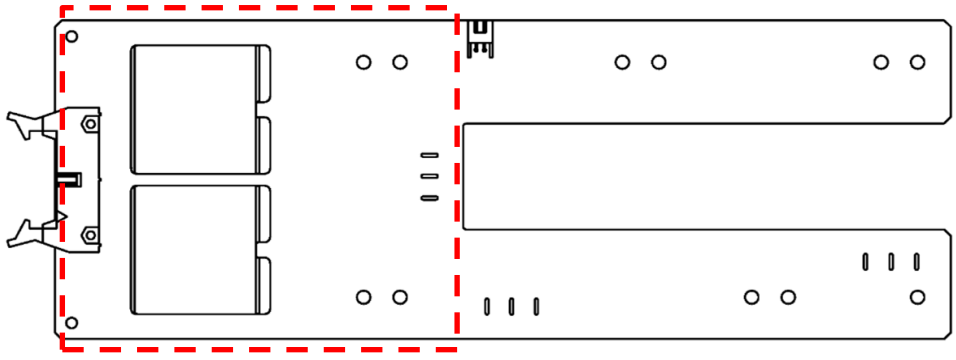
● Make sure the rise/fall time of the input signal is 500ns or less.
Also, keep input wiring as far as possible from noise sources.
To prevent malfunction due to noise, we recommend the highest possible signal voltage within the recommended range.

● Please do not apply excessive stress to this product when attaching to IGBT power module.
Please follow the device manufacturer's instructions on how to install the IGBT power module
(type of screw used, material, tightening torque conditions, etc.).
Also, if the product is exposed to vibration or shock, the PCB should be fixed with spacers as shown in the figure below.





● Handling of this product before IGBT installation
In order to avoid damage to mounted components due to warpage of the PC board,
the product should be gripped within the area indicated by the red dotted line in the figure below.



● This product has DESAT protection for arm short circuit and load short circuit protection.
However, even if this protection works, the IGBT may be damaged if abnormally high current occurs due to IGBT's characteristics variations or the load short-circuit mode during parallel operation.
To ensure safety, be sure to check the short-circuit current at the unit in which this product is integrated,
and evaluate whether it can protect under the condition that there is no damage to the IGBT.

■Important Notice

- This information and product are 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.

- TAMURA has evaluated the efficiency and performance of this product in a usage environment determined by us.
  Depending on your usage environment or usage method, there is the possibility that this product will not perform sufficiently as shown in the specifications, or may malfunction.
  When applying this product to your devices or systems, please ensure that you conduct evaluations of their state when integrated with this product. You are responsible for judging its applicability.
  TAMURA bears no responsibility whatsoever for any problems with your devices,
  systems or this product which are caused by your usage environment or usage method.

- TAMURA Corporation constantly strives to improve quality and reliability, but malfunction or failures are bound to occur with some probability in power products. To ensure that failures do not cause accidents resulting in injury or death, fire accidents, social damage, and so on, you are to thoroughly verify the safety of their designs in devices and/or systems, at your own responsibility.

- 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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