
Trial series “T4001” Inverter Unit Users Manual

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1. Introduction

1.1. Introduction

This users' manual is for T4001 series inverter training kit. These inverters are designed for PMSM motor and induction motor. When you use this inverter, please check your motor specifications like sensor, power, voltage range, current range and so on.

1.2. Suitable use

This inverter is suitable for research or development stage.

1.3. Precaution

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1.4. Warning



- There is a risk of fire.

If you find inverter firing, Fuming, abnormal sounding, or other abnormal conditions, stop the inverter immediately. After you stop the inverter, you should disconnect all wiring connected to the inverter.



- There is a risk of electrical shock.

There is a high voltage parts inside the inverter. Do not touch directly on working or after you stopped the inverter, while there is a charge in the capacitor. If you don't keep this warning, by electric shock, there is a risk of serious injury or death.



- There is a risk of blindness.

This inverter has an enclosure. If the inverter ruptured while opening the lid of the enclosure, there is a possibility the liquid contained in the internal capacitor, such as damaged parts enters the eyes, and it would make you blindness. Please do not open the lid of the enclosure after stopped the inverter immediately, even during the operation. If you open the lid, please be sure to wear goggles for protection such as in the photo below.



Caution

- There is a risk of burns

While driving or after stopped, this inverter gets hot such as more than 100 degree. If you touch the inverter, please pay attention to the temperature.

Caution

- Please do not block the air vents of the enclosure.

In this inverter there is a vent for cooling the inside. If you block the air vent, cooling capacity is reduced. And it may cause the inverter damage or fire.

Caution

- Please drive the FAN while driving the inverter.

In this inverter there is a FAN to cooling the inverter. If you do not drive the FAN while driving the inverter, the temperature of the inverter will rise, it may cause the inverter damage or fire.

Caution

- If you want to create a software, please create the protection routine first, such as over-current protection, over-heat protection and so on.

In this inverter, there is no mechanism to protect the inverter hardware alone. Please make the protection software first, or you may break the inverter.

Caution

- Do not drive the inverter when the ambient is very high or very high humidity.

This inverter is designed for experimental use. So this inverter won't work under below conditions. Do not use under the environment that is out of the operation environment of this manual.

- Environment where there is vibration and shock.
- Environment where there is saprophagous gas, combustible gas, humidity over 90%
- Very High or very low temperature environment

Caution

- This product handling high voltage. Please use a person who is aware of the danger of high voltage.

The wiring materials are enclosed in this inverter for reference. But they do not necessarily mean that they are appropriate for your application. Please use it before check the applications.



Caution

- Rating of this product is measured under certain conditions.

Maximum power capacity would be affected by input voltage output voltage, output current, load conditions, operations conditions and ambient temperature. To prevent the inverter broken, please watch the temperature, current, voltage, and external sensors for to protect inverter.

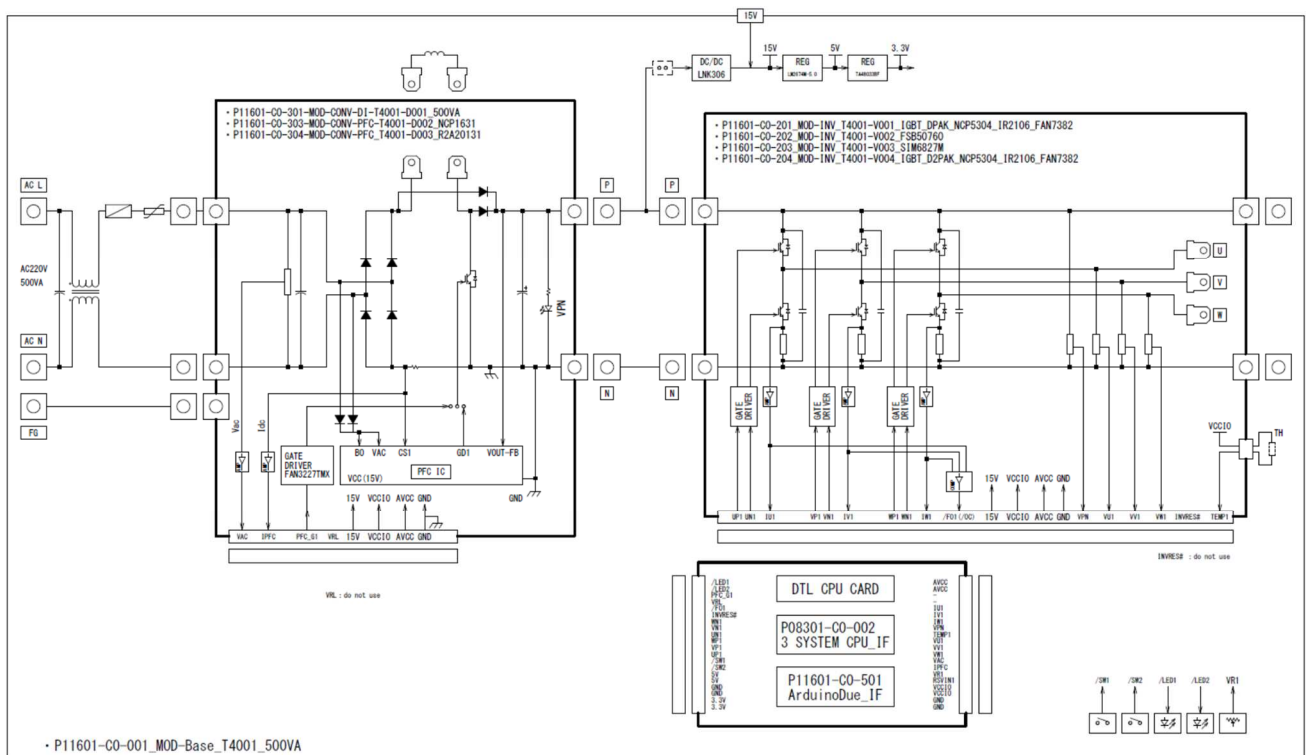
2. Inverter overview

2.1. Feature

This inverter unit is designed for a research or development of consumer use.

- * Non-isolated structure inverter based on an inexpensive circuit for a mass-production.
- * This inverter can be driven by Desk Top Lab CPU cards.
- * Unused CPU pin can be used freely by the user.
- * DC link voltage, three phase output current, three phase output voltage sensor is included.
- * Convenient to experiment, top transparent case, with cooling FAN
- * Inrush current circuits

2.2. Inverter block diagram



2.1. Inverter block diagram

2.3. Specification

This inverter kit includes T4001-BASE (inverter base board), T4001-V001 (DPAK type inverter daughter board), T4001-D001 (Diode bridge daughter board).

T4001-A includes below boards.

T4001-BASE (Inverter base board)

T4001-V001 (DPAK type inverter daughter board)

T4001-D001 (High voltage diode bridge daughter board)

And T4001-A can use Trial series CPU cards.

2.3.1. T4001-BASE (inverter base board) standard attached board

It is a base board for mounting each daughter board. An inverter is constructed by mounting a CPU daughter board, inverter daughter board and rectifier daughter board on this board.

Item	Specifications	Note
Operation temperature	0°C~40°C	
Operation humidity	Below 90% (No dew condensation)	
Size	281 x220 x 170 mm	
Weight	2.2kg	
Case	Transparent acrylic case	
Cooling	Force air cooling	
DC link – control circuit isolation	Non-isolated	
Control power supply	Generated from DC link (Non – isolated)	DC power supply works from DC link voltage 100V
In rush current protection circuits	Available	Power thermistor SK15 5R996
Fuse	10A / 250V	

2.3.2. T4001-D001 (Rectifier daughter board) standard attached board

Item	Specifications	Note
Operation input voltage range	0V~AC265Vrms	
PFC circuits	NA	
Rectifier	GBJ3508	Vr=800V, If=35A
Rectifier circuits type	Full bridge or Voltage doubler	
DC link capacitor	1000uF / 250V × 2	

*Caution: Each maximum value, the rated value, may be changed by the type of load, input voltage, ambient environment, such as by air cooling conditions. Desk top laboratories Inc does not guarantee the condition of all the rated and maximum values of these specifications. Please install the protection way by the customer, depending experimental environment and the load environment.

2.3.3. T4001-V001 (Inverter daughter board DPAK type) Standard attached board

Item	Specification	Remark
Operation voltage range	0V~DC400V	
Rated output current	1Arms (1.41A peak) with heat-sink	This data is for reference only. The temperature depends on the software, switching frequency, load and etc.
Switching frequency	From 2kHz to 20kHz	
Deadtime	Above 1us	
Current sensing method	3 shunt type	Can be changed to 1 shunt type
Shunt resister	50mΩ	
PWM logic	Positive logic	
Main switching devices	ON semi NGTB05N60R2DT4G-D	IGBT DPAK Vces=600V, Ic=8A @100°C
Pre-driver	ON semi NCP5304	IR2106 and FAN7382 can be used by changing resister.
HW over current detection	Comparator	No latch function.
DC link voltage sensor	Resister division method	
3 phase output current sensor	Voltage detector by using shunt resister	
3 phase output voltage sensor	Voltage detector by resister division	3 shunts is default. Can be changed to 1 shunt type
Temperature sensor	NA	With external thermistor input connector

*Caution: Each maximum value, the rated value, may be changed by the type of load, input voltage, ambient environment, such as by air cooling conditions. Desk top laboratories Inc does not guarantee the condition of all the rated and maximum values of these specifications. Please install the protection way by the customer, depending experimental environment and the load environment.

2.3.4. T4001-V002 (Inverter daughter board FSB50760 type) OPTION

Item	Specification	Remark
Operation voltage range	0V~DC400V	
Rated output current	1Arms (1.41A peak)	This data is for reference only. The temperature depends on the software, switching frequency, load and etc.
Switching frequency	2kHz~20kHz	
Deadtime	Above 1us	
Current sensing method	3 shunt type	Can be changed to 1 shunt type
Shunt resister	47mΩ	
PWM logic	Positive logic	
Main switching devices	FairChild FSB50760	
HW over current detection	Comparator	No latch function.
DC link voltage sensor	Resister division method	
3 phase output current sensor	Voltage detector by using shunt resister	
3 phase output voltage sensor	Voltage detector by resister division	3 shunts is default. Can be changed to 1 shunt type
Temperature sensor	IPM internal sensor	

*Caution: Each maximum value, the rated value, may be changed by the type of load, input voltage, ambient environment, such as by air cooling conditions. Desk top laboratories Inc does not guarantee the condition of all the rated and maximum values of these specifications. Please install the protection way by the customer, depending experimental environment and the load environment.

2.3.5. T4001-V003 (Inverter daughter board SIM6827M type) OPTION

Item	Specification	Remark
Operation voltage range	0V~DC400V	
Rated output current	1Arms (1.41A peak)	This data is for reference only. The temperature depends on the software, switching frequency, load and etc.
Switching frequency	2kHz~20kHz	
Deadtime	Above 1us	
Current sensing method	3 shunt type	Can be changed to 1 shunt type
Shunt resister	47mΩ	
PWM logic	Positive logic	
Main switching devices	SANKEN SIM6827M	
HW over current detection	IPM includes this function	No latch function.
DC link voltage sensor	Resister division method	
3 phase output current sensor	Voltage detector by using shunt resister	
3 phase output voltage sensor	Voltage detector by resister division	3 shunts is default. Can be changed to 1 shunt type
Temperature sensor	IPM internal sensor	

*Caution: Each maximum value, the rated value, may be changed by the type of load, input voltage, ambient environment, such as by air cooling conditions. Desk top laboratories Inc does not guarantee the condition of all the rated and maximum values of these specifications. Please install the protection way by the customer, depending experimental environment and the load environment.

2.3.6. T4001-V004 (Inverter daughter board D2PAK LDK type) OPTION

Item	Specification	Remark
Operation voltage range	0V~DC400V	
Rated output current	1Arms (1.41A peak)	This data is for reference only. The temperature depends on the software, switching frequency, load and etc.
Switching frequency	2kHz~20kHz	
Deadtime	Above 1us	
Current sensing method	3 shunt type	Can be changed to 1 shunt type
Shunt resister	47mΩ	
PWM logic	Positive logic	
Main switching devices	RJH60D2	RENESAS
Pre-driver	ON semi NCP5304	IR2106 and FAN7382 can be used by changing resister.
HW over current detection	Comparator	No latch function.

DC link voltage sensor	Resister division method	
3 phase output current sensor	Voltage detector by using shunt resister	
3 phase output voltage sensor	Voltage detector by resister division	3 shunts is default. Can be changed to 1 shunt type
Temperature sensor	IPM internal sensor	

*Caution: Each maximum value, the rated value, may be changed by the type of load, input voltage, ambient environment, such as by air cooling conditions. Desk top laboratories Inc does not guarantee the condition of all the rated and maximum values of these specifications. Please install the protection way by the customer, depending experimental environment and the load environment.

2.3.7. T4001-V005 (Inverter daughter board low voltage TO-220 type) OPTION

Item	Specification	Remark
Operation voltage range	0V~DC48V	
Rated output current	14[A rms]	This data is for reference only. The temperature depends on the software, switching frequency, load, deadtime and etc.
Switching frequency	2kHz~20kHz	
Deadtime	Above 1us	
Current sensing method	3 shunt type	Can be changed to 1 shunt type
Shunt resister	5mΩ	
PWM logic	Positive logic	
Main switching devices	RJK1008	RENESAS
Pre-driver	ON semi NCP5304	IR2106 and FAN7382 can be used by changing resister.
HW over current detection	Comparator	No latch function.
DC link voltage sensor	Resister division method	
3 phase output current sensor	Voltage detector by using shunt resister	
3 phase output voltage sensor	Voltage detector by resister division	3 shunts is default. Can be changed to 1 shunt type
Temperature sensor	IPM internal sensor	

*Caution: Each maximum value, the rated value, may be changed by the type of load, input voltage, ambient environment, such as by air cooling conditions. Desk top laboratories Inc does not guarantee the condition of all the rated and maximum values of these specifications. Please install the protection way by the customer, depending experimental environment and the load environment.

2.3.8. T4001-V006 (Inverter daughter board high voltage TO-220 type) OPTION

Item	Specification	Remark
Operation voltage range	0V~DC400V	
Rated output current	2[A rms]	This data is for reference only. The temperature depends on the software, switching frequency, load and etc.
Switching frequency	2kHz~20kHz	
Deadtime	Above 1us	
Current sensing method	3 shunt type	Can be changed to 1 shunt type
Shunt resister	50mΩ	
PWM logic	Positive logic	
Main switching devices	NA	
Pre-driver	ON semi NCP5304	IR2106 and FAN7382 can be used by changing resister.
HW over current detection	Comparator	No latch function.
DC link voltage sensor	Resister division method	
3 phase output current sensor	Voltage detector by using shunt resister	
3 phase output voltage sensor	Voltage detector by resister division	3 shunts is default. Can be changed to 1 shunt type
Temperature sensor	IPM internal sensor	

*Caution: Each maximum value, the rated value, may be changed by the type of load, input voltage, ambient environment, such as by air cooling conditions. Desk top laboratories Inc does not guarantee the condition of all the rated and maximum values of these specifications. Please install the protection way by the customer, depending experimental environment and the load environment.

3.1.3. ON board switch (T4001-BASE)



T4001-BASE has two toggle switches. But **YOU MUST NOT USE THESE SWITCHES**, while you are using with high voltage. Or you might die because of the electric shock. These switches are test purpose, for low voltage use.

3.1.4. ON board variable resistor (T4001-BASE)

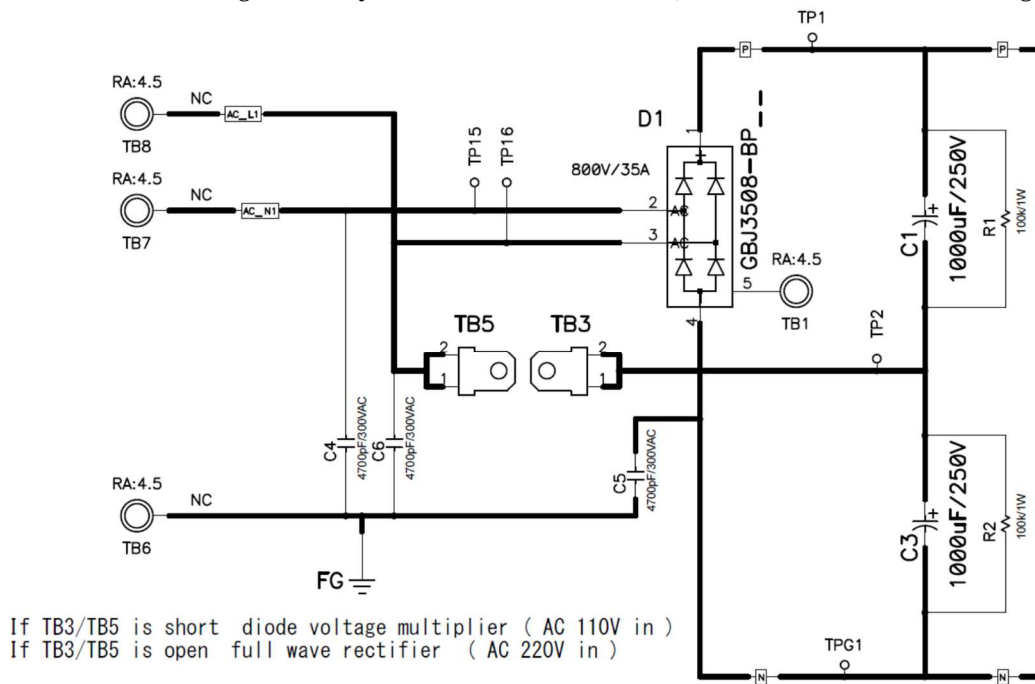


T4001-BASE has one variable resistor. But **YOU MUST NOT USE THIS VR**, while you are using with high voltage. Or you might die because of the electric shock. This VR is test purpose, for low voltage use.

3.2. Precaution for T4001-D001 rectifier board

3.2.1. Selection for rectifier circuits (Rectifier daughter board T4001-D001)

T4001-D001 daughter board can choose full bridge or voltage doubler. If you cut TB3 and TB5(default), the circuits work as a full bridge. And if you connect TB3 and TB5, the circuits work as a voltage doubler.



If you choose the “voltage doubler” circuits, and you apply more than AC160V. The main circuits might explode.

3.3. Precaution for T4001-V001 inverter daughter board (DPAK type)

3.3.1. Heat-sink (T4001-V001 DPAK type)

T4001-V001 has heat-sink and other parts as accessories.

3.3.2. Selection of the current detection circuits (T4001-V001 DPAK type)

There are two outputs of the current detection circuits of this inverter. Two outputs are selected by JP2, JP3, JP4, JP5. Please choose JP setting according to your CPU setting.

$AV_{cc} = 5V$ 時

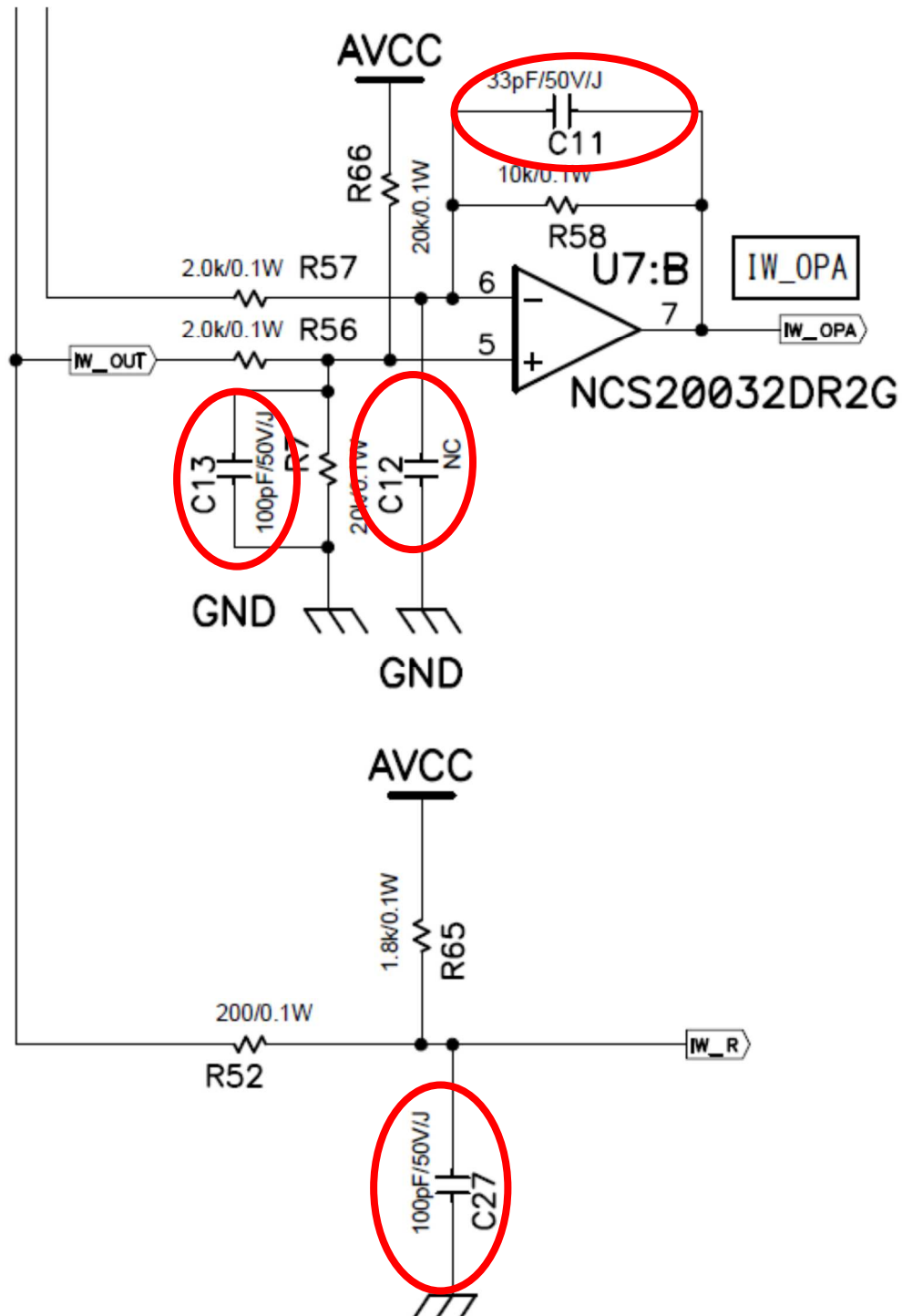
JP	1-2 Short, 2-3 Open		1-2 Open, 2-3 Short	
	Outputs	Equations	Outputs	Equations
JP4	Iu OPAMP selection	$V_{out} = (10 * R * I_{in} + AV_{cc}) / 2$ $R = 50m\Omega$ $I_{in} = 10A \rightarrow V_{out} = 5V$ $I_{in} = 0A \rightarrow V_{out} = 2.5V$ $I_{in} = -10A \rightarrow V_{out} = 0V$	Iu direct output	$V_{out} = (9 * R * I_{in} + AV_{cc}) / 2$ $R = 50m\Omega$ At internalOPAGain=5 $I_{in} = 11.11A \rightarrow V_{out} = 5V$ $I_{in} = 0A \rightarrow V_{out} = 2.5V$ $I_{in} = -11.11A \rightarrow V_{out} = 0V$
JP5	Iv OPAMP selection		Iv direct output	
JP6	Iw OPAMP selection		Iw direct output	

$AV_{cc} = 3.3V$ 時

JP	1-2 Short, 2-3 Open		1-2 Open, 2-3 Short	
	Outputs	Equations	Outputs	Equations
JP4	Iu OPAMP selection	$V_{out} = (10 * R * I_{in} + AV_{cc}) / 2$ $I_{in} = 6.6A \rightarrow V_{out} = 3.3V$ $I_{in} = 0A \rightarrow V_{out} = 1.65V$ $I_{in} = -6.6A \rightarrow V_{out} = 0V$	Iu direct output	$V_{out} = (9 * R * I_{in} + AV_{cc}) / 2$ At internalOPAGain=5 $I_{in} = 7.33A \rightarrow V_{out} = 3.3V$ $I_{in} = 0A \rightarrow V_{out} = 1.65V$ $I_{in} = -7.33A \rightarrow V_{out} = 0V$
JP5	Iv OPAMP selection		Iv direct output	
JP6	Iw OPAMP selection		Iw direct output	

3.3.3. The filter circuits for the current detection (T4001-V001 DPAK type)

The filter parameters for the current detection circuits need be changed by the application, noise environment, switching frequency, control algorithm and so on. As shown below, this inverter provides the pattern of the filter capacitor.

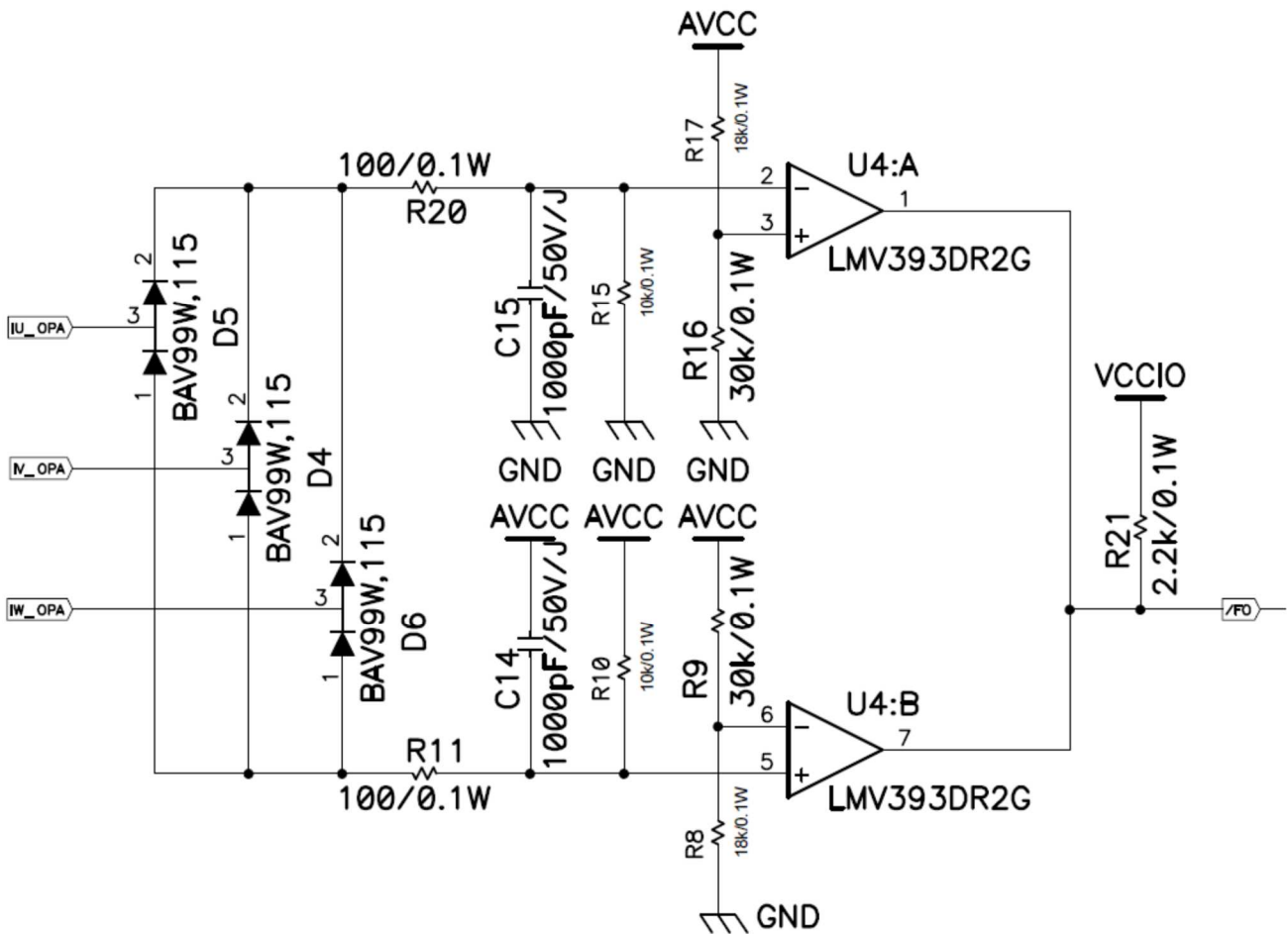


3.3.4. Alterations for one shunt current detection method (T4001-V001 DPAK type)

This inverter is based on three shunt current detection. But this inverter can be converted to the one shunt current detection. If you want to use one shunt current detection method, please connect TP11, TP12 and TP13 hole. In case of this alteration, resistor value will be 1/3. You need to change the resistor value or remove resistors depending on your requirement.

3.3.5. Over current detection circuits

The over current detection circuits of this inverter use the comparators. The outputs of the comparators are connected to the /INT pin of CPU. So user need to install the gate-block routine to your application.



3.3.6. Voltage detection circuits (T4001-V001 DPAK type)

This inverter has four voltage detection circuits.

At $V_{cc} = 5V$

Voltage	Equation
DC link	$V_{out} = \frac{5.0}{686.8} \times V_{in}$
U phase	
V phase	
W phase	$V_{in}=686.8V \rightarrow V_{out}=5V$ $V_{in}=0V \rightarrow V_{out}=0V$

At $V_{cc} = 3.3V$

Voltage	Equation
DC link	$V_{out} = \frac{3.3}{453.3} \times V_{in}$
	$V_{in}=453.3V \rightarrow V_{out}=3.3V$ $V_{in}=0V \rightarrow V_{out}=0V$

3.4. How to choose CPU voltage

This inverter board automatically supplies the proper CPU voltage. You don't worry about how to choose CPU voltage.

3.5. Connection information with CPU board

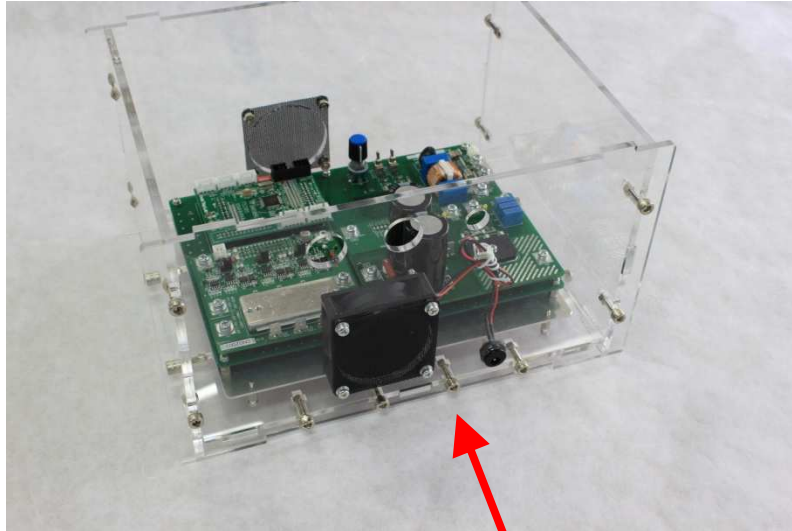
CN-A Digital	Direction	STD Inverter	T5201 RX62T 100pin	T5205 RX23T 64pin	T5206 TX24T 100pin	T5101 RL78G14 64pin	T5102 RL78F14 80pin	T5103 RL78G1F 64pin	T5104 RL78G1G 32pin	T5104 RL78G14 32pin	T5301 RX111 64pin
1	To INV	-	PA2	P00	PA2	P52	P44	P141	P60	P60	P32
2	To INV	-	PA3	P01	PA1	P53	P47	P140	P61	P61	PB0
3	To INV	PFC_G1	PD0	P31	PD7	P54	P41	P04	-	-	PA1
4	To INV	VRL	PB3	PB4	PB3	P55	P42	P55	-	-	PA0
5	To CPU	/FO	P70	P70	P70	P137	P137	P137	P137	P137	PB5
6	To INV	/INVRES			P55						
7	To INV	WN	P76	P76	P76	P10	P30	P10	P10	P10	P55
8	To INV	VN	P75	P75	P75	P11	P16	P11	P11	P11	PB1
9	To INV	UN	P74	P74	P74	P14	P120	P14	P14	P14	PB6
10	To INV	WP	P73	P73	P73	P12	P17	P12	P12	P12	P54
11	To INV	VP	P72	P72	P72	P13	P15	P13	P13	P13	PB3
12	To INV	UP	P71	P71	P71	P15	P125	P15	P15	P15	PB7
13	To CPU		P91	P91	P80	P05	P46	P05	P70	P70	P35
14	To CPU		P92	P92	P81	P06	P45	P06	P17	P17	P31
15	To CPU	5V	5V	5V	5V	5V	5V	5V	5V	5V	5V
16	To CPU	5V	5V	5V	5V	5V	5V	5V	5V	5V	5V
17	To CPU	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND
18	To CPU	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND
19	To CPU	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V
20	To CPU	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V

CN-B Analog	Direction	STD Inverter	T5201 RX62T 100pin	T5105 RX23T	T5206 TX24T	T5101 RL78G14 64pin	T5102 RL78F14 80pin	T5103 RL78G1F 64pin	T5104 RL78G1G 32pin	T5104 RL78G14 32pin	T5301 RX111 64pin
1	To INV	AVCC	5V	5V	5V	5V	5V	5V	5V	5V	3.3V
2	To INV	AVCC	5V	5V	5V	5V	5V	5V	5V	5V	3.3V
3	To CPU	(RSV)			P42 AN002						
4	To CPU	(RSV)			P43 AN003						
5	To CPU	IU	ANI 000	AN000	AN100	ANI 0	ANI 2	ANI2	ANI0	ANI0	ANI 0
6	To CPU	IV	ANI 001	AN001	AN101		ANI 4	-	ANI1	ANI1	ANI 1
7	To CPU	IW	ANI 002	AN002	AN102	ANI 1	ANI 3	ANI3	ANI2	ANI2	ANI 2
8	To CPU	VPN	ANI 003	AN003	AN204	ANI 2	ANI 8	ANI4	ANI3	ANI3	ANI 3
9	To CPU	TEMP (Vot)	ANI 0	AN007	AN205	ANI 7	ANI 10	ANI7	-	-	ANI 4
10	To CPU	VU	ANI 101	AN004	AN201	ANI 3	ANI 5	ANI16	ANI17	ANI17	ANI 6

11	To CPU	VV	ANI 102	AN005	AN202	ANI 4	ANI 6	ANI0	ANI18	ANI18	ANI 8
12	To CPU	VW	ANI 103	AN006	AN203	ANI 5	ANI 7	ANI1	ANI19	ANI19	ANI 11
13	To CPU	(VAC)	ANI 1	AN016	AN207	r ANI 16	ANI 9	ANI5	-	-	ANI 12
14	To CPU	(IPFC)	ANI 100	(AN017)	AN208	r ANI 17	ANI 13	ANI18	-	-	ANI 13
15	To CPU	(VR1)	ANI 2	AN017	AN209	ANI 6	ANI 11	ANI6	ANI10	ANI10	ANI 14
16	To CPU	(RSV)	ANI 3	-	AN210	ANI 19	ANI 12	ANI17 (Yin)	-	-	ANI 15
17	To INV	VCCIO	5V	5V	5V	5V	5V	5V	5V	5V	3.3V
18	To INV	VCCIO	5V	5V	5V	5V	5V	5V	5V	5V	3.3V
19	To CPU	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND
20	To CPU	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND

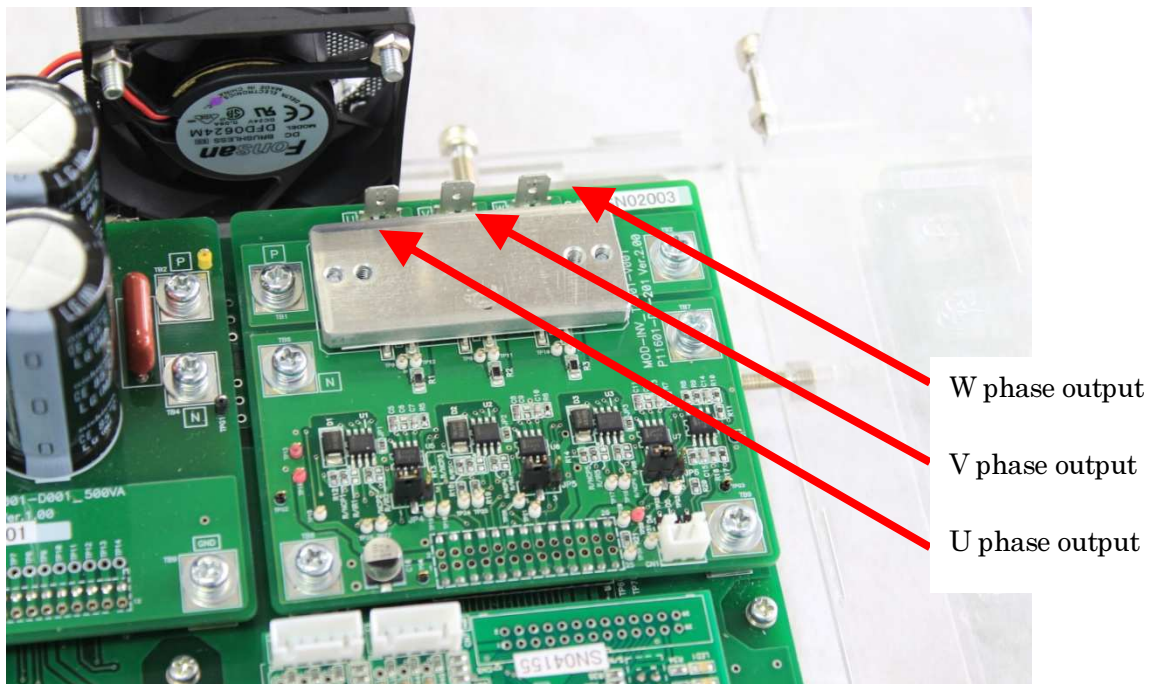
4. External connection

4.1. FAN power input

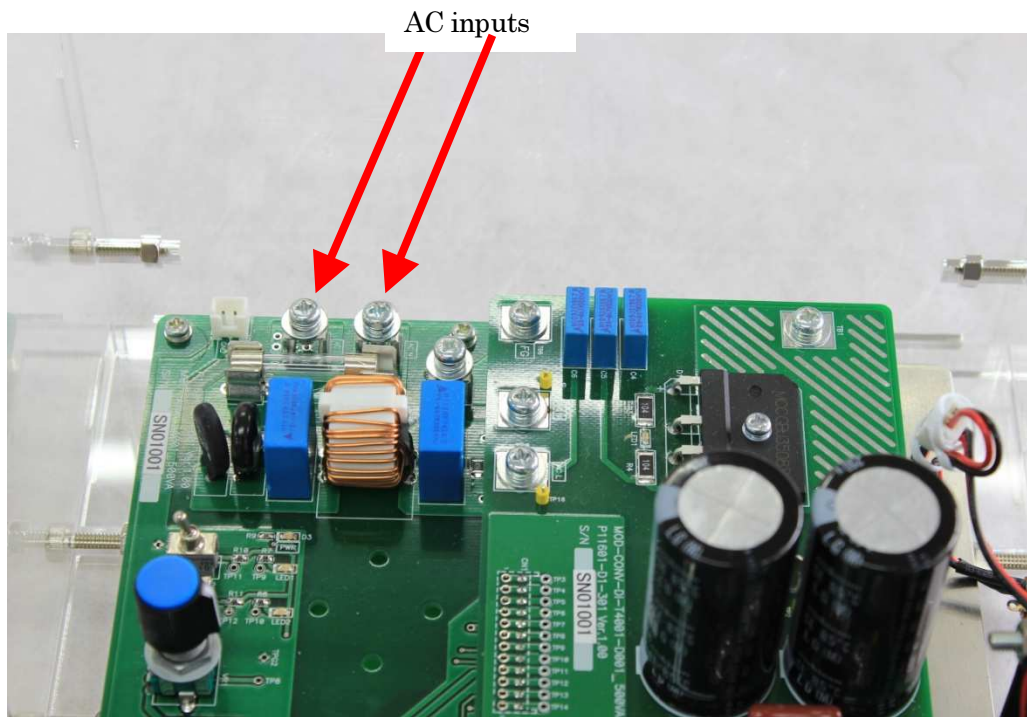


Connect FAN power input connector

4.2. Inverter AC output



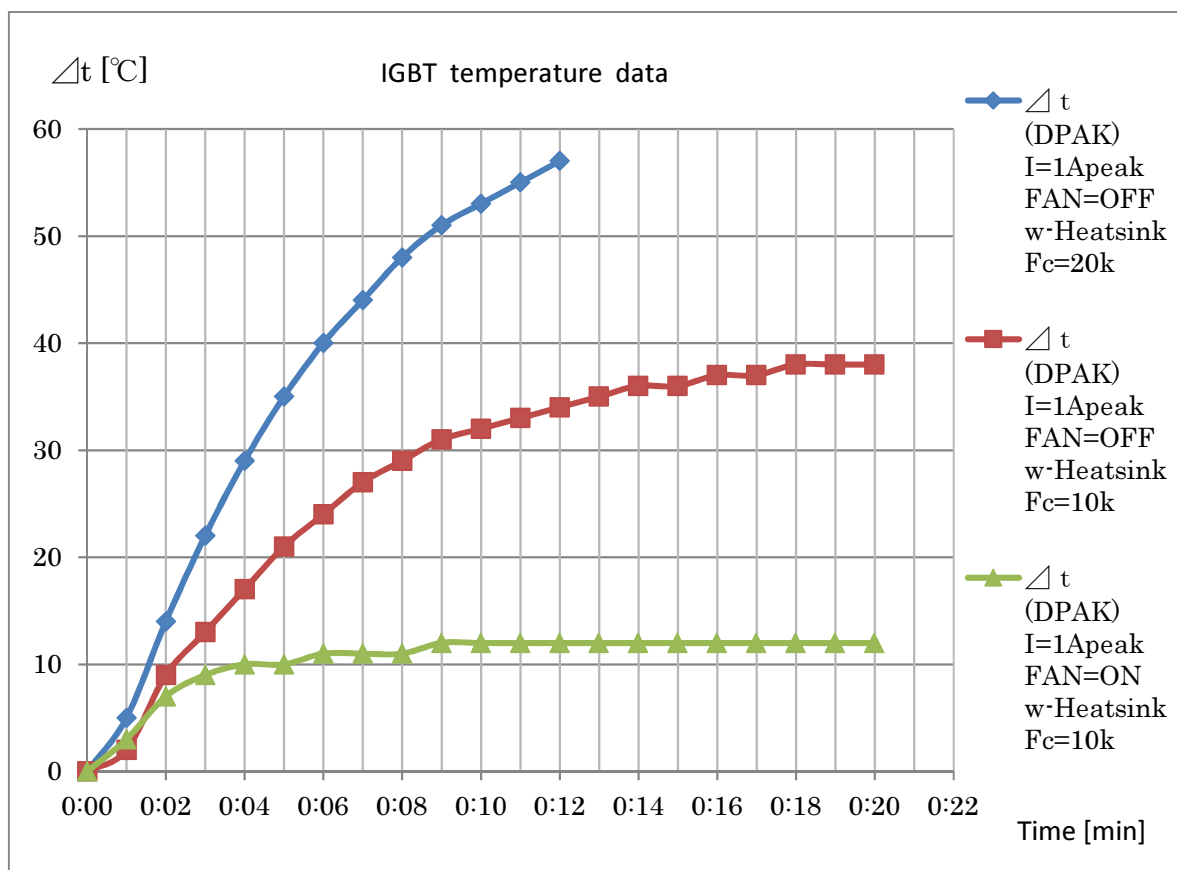
4.3. Inverter AC input



5. Temperature raise value data for T4001-V001

5.1. Temperature raise value data (T4001-V001)

This is example of the temperature raise value data of this inverter.
If you stop the FAN when you driving the inverter, the inverter may get very high temperature and would be broken. Please make sure to run FAN, when you drive the inverter.



5.2. Temperature raise value data (T4001-V005)

This is example of the temperature raise value data of this inverter.
If you stop the FAN when you driving the inverter, the inverter may get very high temperature and would be broken. Please make sure to run FAN, when you drive the inverter.

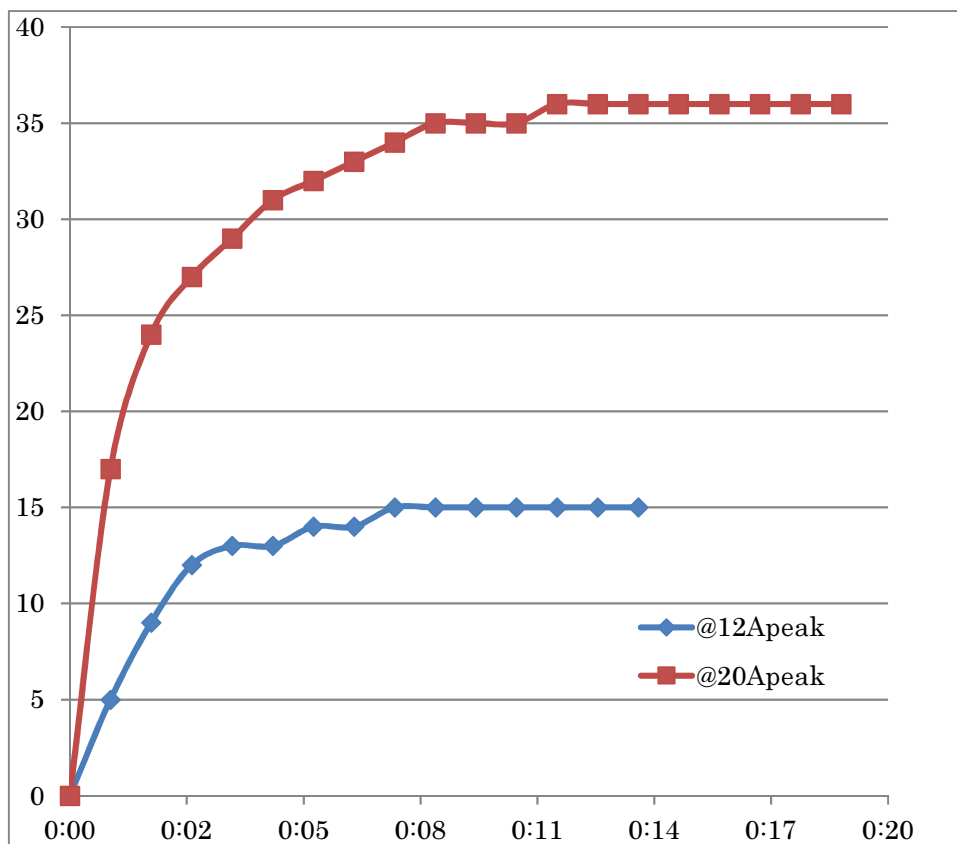
V_{dc} = 48V

Ambient temp = 22deg

Forced cooling

Deadtime 2us

Carrier = 10kHz



5.3. Temperature raise value data (T4001-V006)

This is example of the temperature raise value data of this inverter.
If you stop the FAN when you driving the inverter, the inverter may get very high temperature and would be broken. Please make sure to run FAN, when you drive the inverter.

V_{dc} = 250V

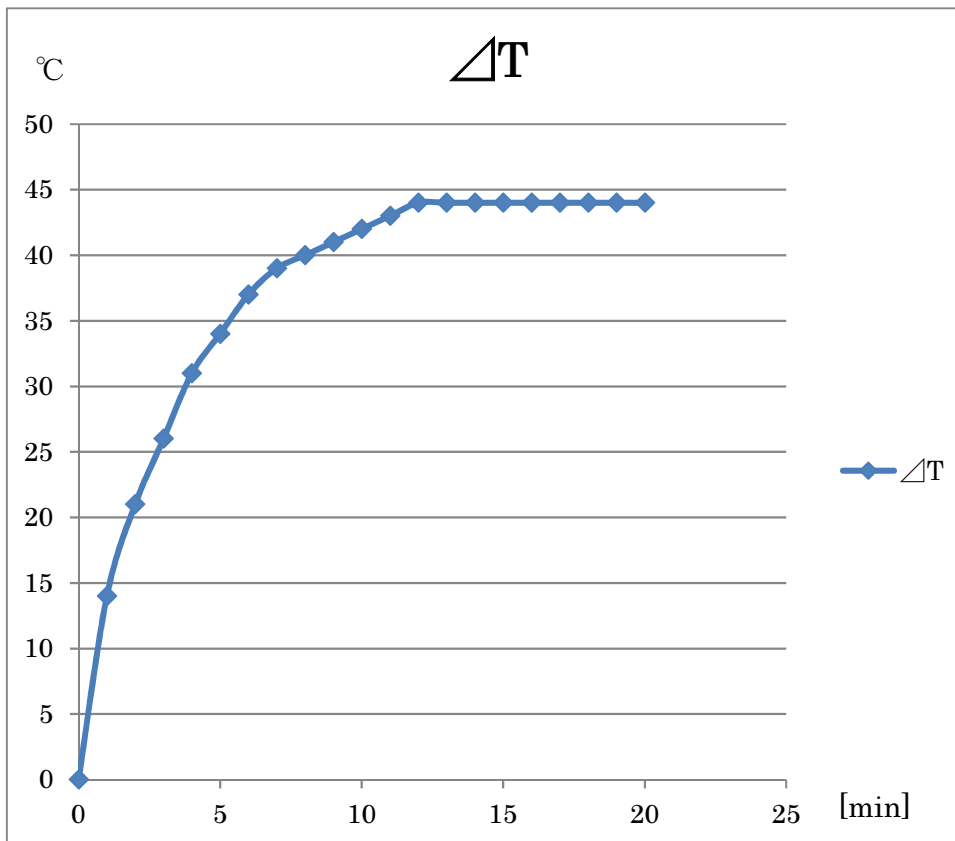
Ambient temp = 20deg

No cooling

Deadtime 2us

Carrier = 10kHz

Phase current = 3[A_{peak}]



6. Ordering information

6.1. Order number list

Order number	FAN	Case
T4001	DC	T4001-BASE T4001-D001 T4001-V001 Acryl case AC adopter for FAN

OPTION

OPTION	内容
T4001-D001	Rectifier daughter board
T4001-V001	DPAK inverter daughter board
T4001-V002	Fairchild/ON semi FSB50760SF inverter daughter board
T4001-V003	SANKEN SIM6827M inverter daughter board
T4001-V004	D2PAK/LDPAK inverter daughter board
T4001-V005	DC48V TO-220 inverter daughter board
T4001-V006	DC400V TO-220 inverter daughter board

7. History

7.1. History

Date	Remark
Ver.1.02 EN	・ First release
Ver.1.05 EN	・ Add T4001-V005, T4001-V006

Trial series T4001 Inverter Unit Users Manual

Issue date: Jan-18-2019 Ver.1.05 EN

Issue: Desk Top Laboratories Inc.
101, 35-7, MATSUGI, HACHIOUJI-SHI, TOKYO, Japan, 192-0362
