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Trial series  
T2003C-A 1kW  
Low Voltage Inverter Unit  
Users Manual

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## 1. Introduction

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### 1.1. Introduction

This users' manual is for T2003C-A low voltage 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 user

This inverter is suitable for research or development stage.

### 1.3. Caution

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### 1.4. Warning



#### **Danger**

- **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.



#### **Danger**

- **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.



#### **Danger**

- **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.



- **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.



- **Please do not block the air vents of the enclosure. (only for T2000B)**

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.



- **Please drive the FAN while driving the inverter. (only for T2000B)**

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.



- **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.



- **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 is driven by RL78G14, RL78F14, RX13T, RX23T, RX24T, RX62T, RX66T, RX72T, RH850F1KM-S1 and so on.
- \* 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.

### 2.2. Inverter block diagram

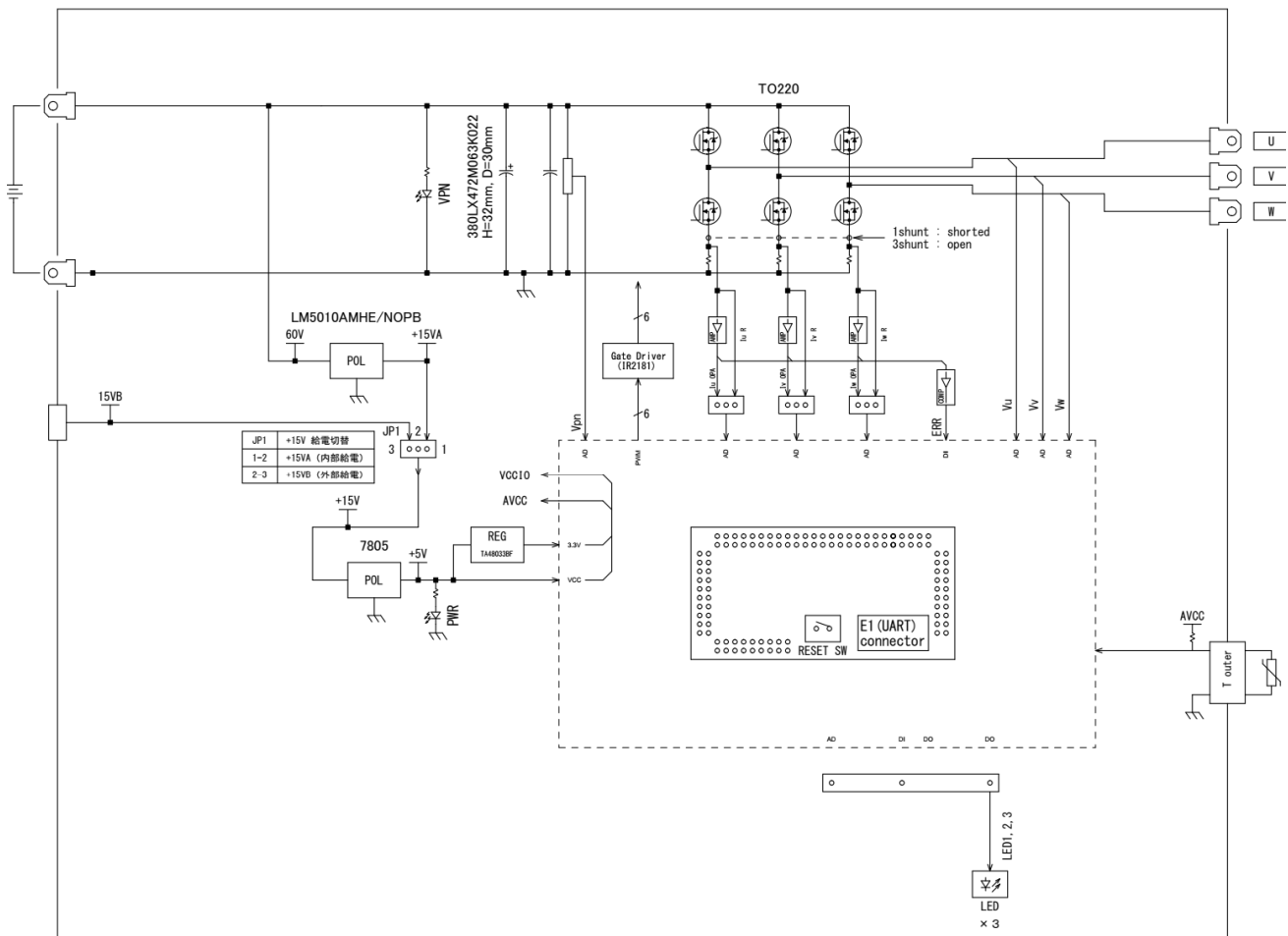


Fig.2.1. Inverter block diagram

## 2.3. T2003C-A specifications

Item	Specifications	Note
Operation temperature	0°C~35°C	
Operation humidity	Below 90% (No dew condensation)	
Size	280 x 210 x 180 mm	
Weight	2.6kg	
Input voltage range	DC12V~DC48V	
Maximum output power	1kW / 1.2kVA @ DC48Vinput	
Rated output current	30Apeak	@ switching frequency 15kHz
Switching frequency	2kHz~20kHz	This value is for your information
Deadtime	Above 1us	This value is for your information.
Current detection	3 shunt	User can modify for 1 shunt current detection
Shunt register	5mΩ	
Switching device	RJK1008DPP	RENESAS
Control power supply	Generated from DC link	Non-isolated
DC link – control circuit isolation	Non-isolated	
Cooling	Forced air cooling with DC FAN	
PFC controller	No	
Temperature sensor	No	
ICS	No	

\*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. Precautions for each circuits blocks

#### 3.1. Choice of the current detection circuits

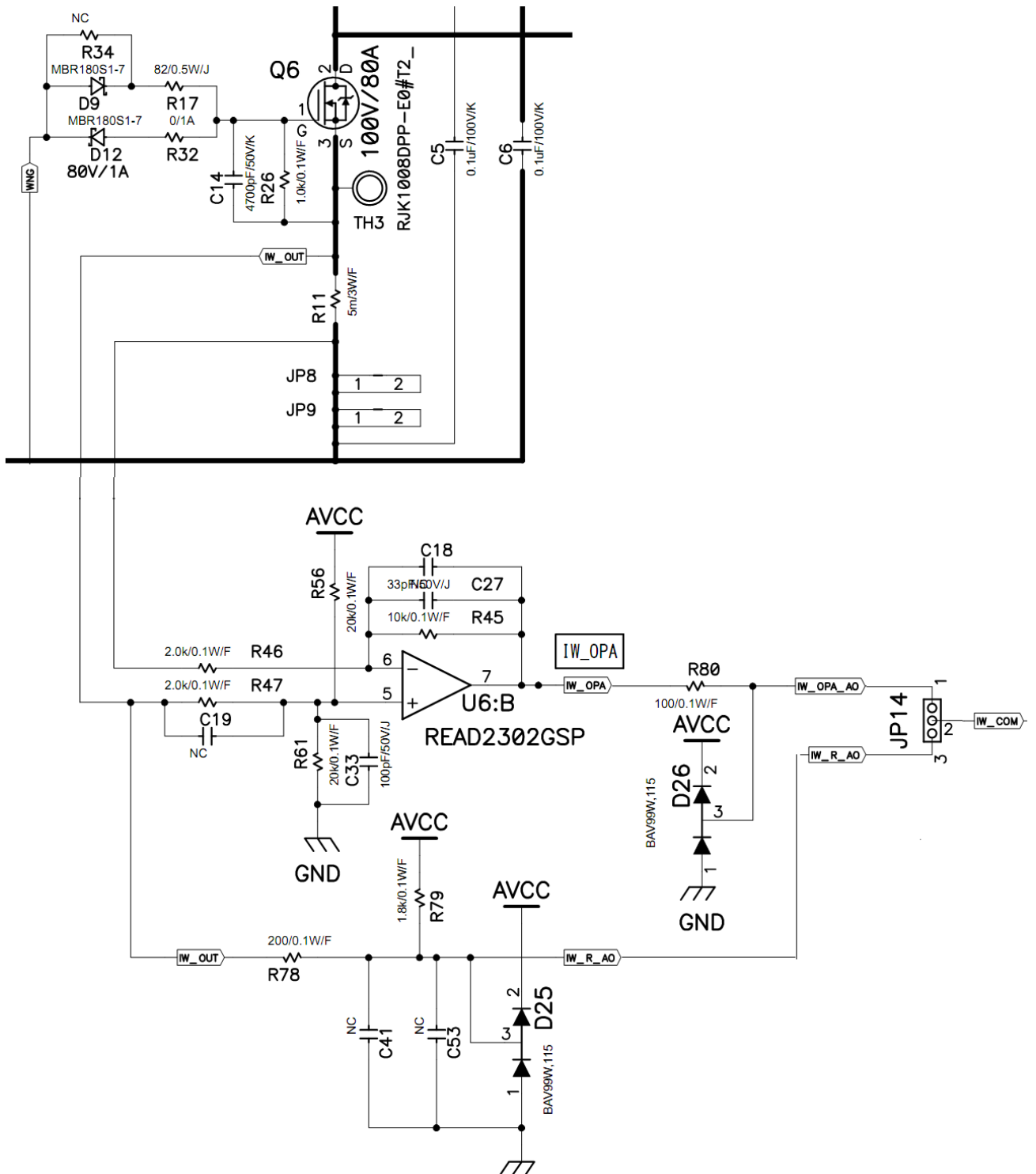
There are two outputs of the current detection circuits of this inverter. Two outputs are selected by JP12, JP13, JP14. Please choose JP setting according to your CPU setting.

T2003 C-A @AVcc = 5V

JP	1-2 Short, 2-3 Open		1-2 Open, 2-3 Short	
	Outputs	Equations	Outputs	Equations
JP12	Iu OPAMP output	$V_{out} = (10 * R * I_{in} + AV_{cc}) / 2$ $I_{in}=100A \rightarrow V_{out}=5V$ $I_{in}=0A \rightarrow V_{out}=2.5V$ $I_{in}=-100A \rightarrow V_{out}=0V$	Iu direct output	$V_{out} = (9 * R * I_{in} + AV_{cc}) / 2$ At internalOPAGain=5 $I_{in}=111A \rightarrow V_{out}=5V$ $I_{in}=0A \rightarrow V_{out}=2.5 V$ $I_{in}=-111A \rightarrow V_{out}=0V$
JP13	Iv OPAMP output		Iv direct output	
JP14	Iw OPAMP output		Iw direct output	

T2003C-A @AVcc = 3.3V

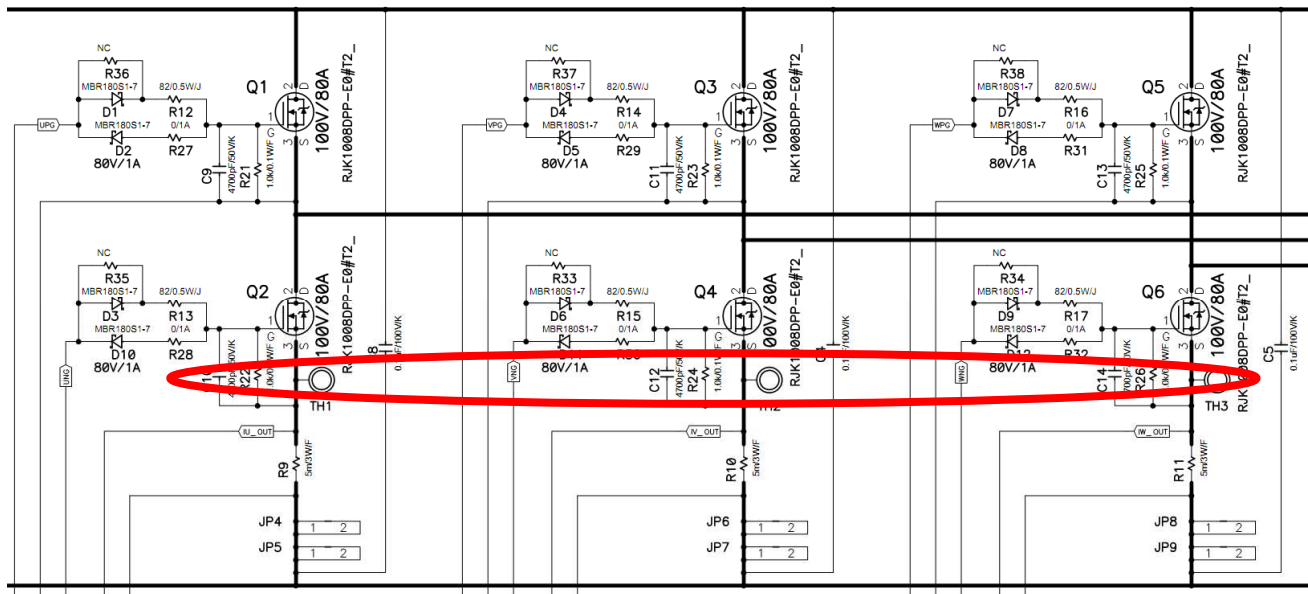
JP	1-2 Short, 2-3 Open		1-2 Open, 2-3 Short	
	Outputs	Equations	Outputs	Equations
JP12	Iu OPAMP output	$V_{out} = (10 * R * I_{in} + AV_{cc}) / 2$ $I_{in}=66A \rightarrow V_{out}=3.3V$ $I_{in}=0A \rightarrow V_{out}=1.65V$ $I_{in}=-66A \rightarrow V_{out}=0V$	Iu direct output	$V_{out} = (9 * R * I_{in} + AV_{cc}) / 2$ At internalOPAGain=5 $I_{in}=73.3A \rightarrow V_{out}=3.3V$ $I_{in}=0A \rightarrow V_{out}=1.65 V$ $I_{in}=-73.3A \rightarrow V_{out}=0V$
JP13	Iv OPAMP output		Iv direct output	
JP14	Iw OPAMP output		Iw direct output	





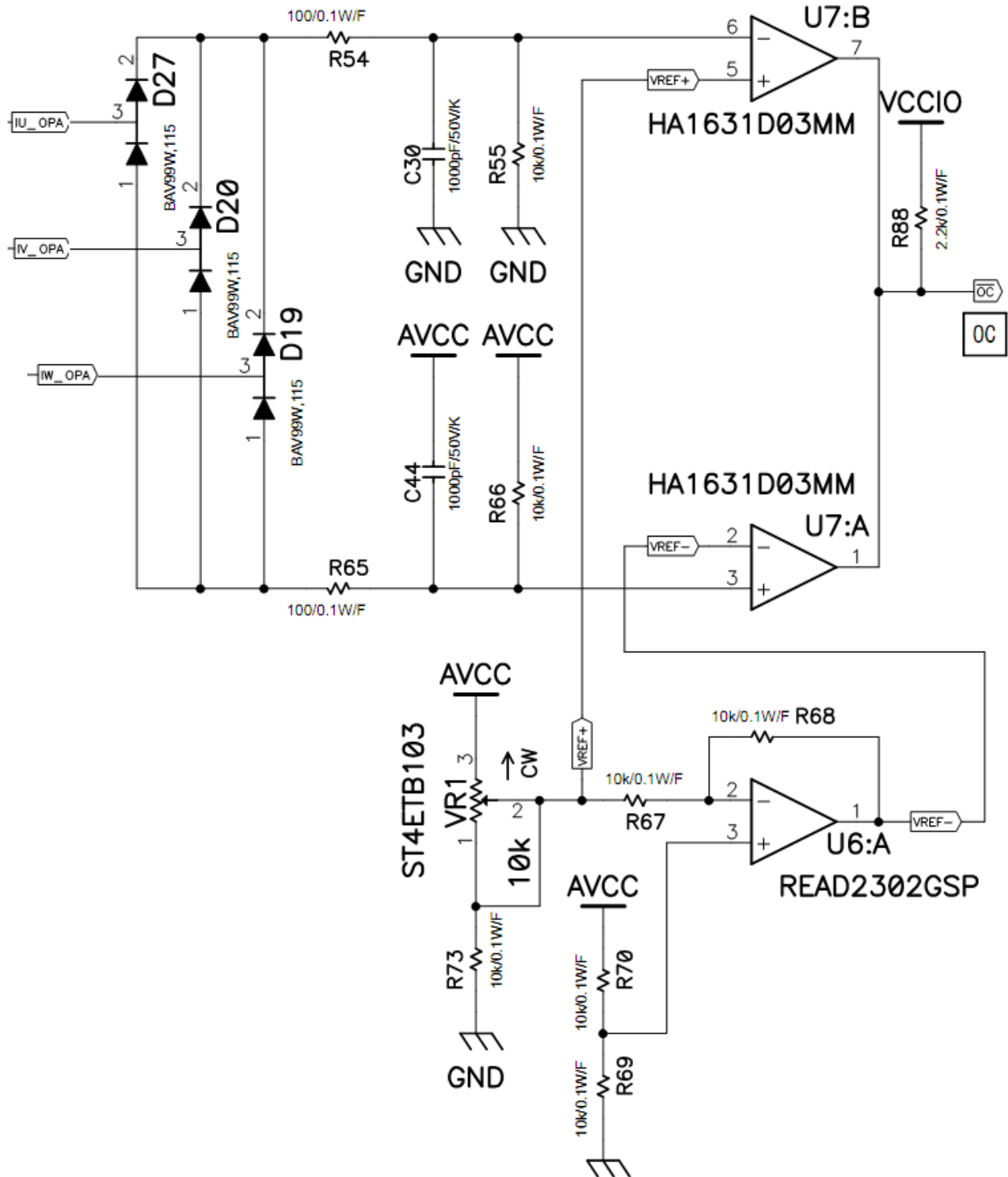
## 3.3. Alterations for one shunt current detection method

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 TH1, TH2 and TH3 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.



## 3.4. 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.



3.5. Voltage detection circuits

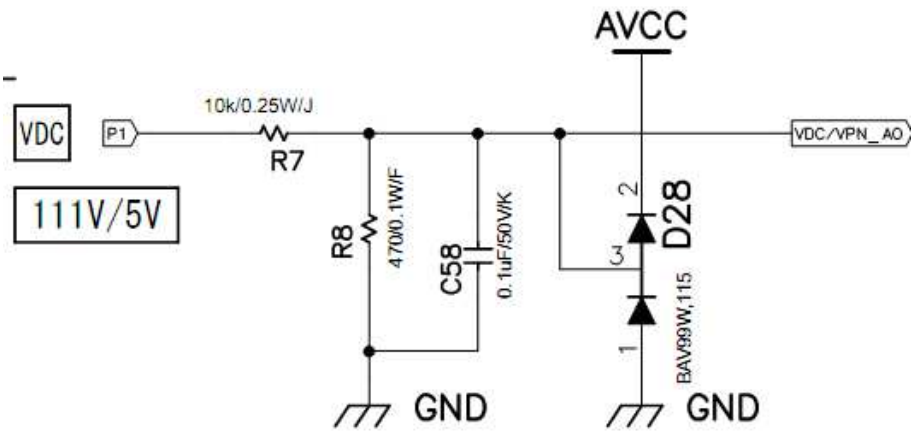
This inverter has four voltage detection circuits.

AVcc = @5V

Voltage	equations
DC link	$V_{out} = \frac{0.47k}{10k + 0.47k} \times V_{in}$
U phase	
V phase	
W phase	$V_{in}=111V \rightarrow V_{out}=5V$ $V_{in}=0V \rightarrow V_{out}=0V$

AVcc = @3.3V

Voltage	equations
DC link	$V_{out} = \frac{0.47k}{10k + 0.47k} \times V_{in}$
U phase	
V phase	
W phase	$V_{in}=73.5V \rightarrow V_{out}=3.3V$ $V_{in}=0V \rightarrow V_{out}=0V$



3.6. How to choose CPU voltage

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

## 3.7. Connection information with CPU board

CN-A Digital	Direction	STD Inverter	T5201 RX62T 100pin *1		T5101 RL78/G14 64pin	T5301 RX111 64pin	T5102 RL78/F14 80pin	
1	To INV	–	PA2		P52	P32	P44	
2	To INV	–	PA3		P53	PB0	P47	
3	To INV	PFC_G1	PD0		P54	PA1	P41	
4	To INV	VRL	PB3		P55	PA0	P42	
5	To CPU	/FO	P70		P137	PB5	P137	
6	To CPU	–						
7	To INV	WN	P76		P10	P55	P30	
8	To INV	VN	P75		P11	PB1	P16	
9	To INV	UN	P74		P14	PB6	P120	
10	To INV	WP	P73		P12	P54	P17	
11	To INV	VP	P72		P13	PB3	P15	
12	To INV	UP	P71		P15	PB7	P125	
13	To CPU		P91		P05	P35	P46	
14	To CPU		P92		P06	P31	P45	
15	To CPU	5V	5V		5V	5V	5V	
16	To CPU	5V	5V		5V	5V	5V	
17	To CPU	GND	GND		GND	GND	GND	
18	To CPU	GND	GND		GND	GND	GND	
19	To CPU	3.3V	3.3V		3.3V	3.3V	3.3V	
20	To CPU	3.3V	3.3V		3.3V	3.3V	3.3V	

CN-B Analog	Direction	STD Inverter	T5201 RX62T 100pin *1		T5101 RL78/G14 64pin	T5301 RX111 64pin	T5102 RL78/F14 80pin	
1	To INV	AVCC	5V		5V	3.3V	5V	
2	To INV	AVCC	5V		5V	3.3V	5V	
3	To CPU	–						
4	To CPU	–						
5	To CPU	IU	ANI 000		ANI 0	ANI 0	ANI 2	
6	To CPU	IV	ANI 001			ANI 1	ANI 4	
7	To CPU	IW	ANI 002		ANI 1	ANI 2	ANI 3	
8	To CPU	VPN	ANI 003		ANI 2	ANI 3	ANI 8	
9	To CPU	TEMP(Vot)	ANI 0		ANI 7	ANI 4	ANI 10	
10	To CPU	VU	ANI 101		ANI 3	ANI 6	ANI 5	
11	To CPU	VV	ANI 102		ANI 4	ANI 8	ANI 6	
12	To CPU	VW	ANI 103		ANI 5	ANI 11	ANI 7	
13	To CPU	(VAC)	ANI 1		r ANI 16	ANI 12	ANI 9	
14	To CPU	(IPFC)	ANI 100		r ANI 17	ANI 13	ANI 13	
15	To CPU	(VR1)	ANI 2		ANI 6	ANI 14	ANI 11	
16	To CPU	(RSV)	ANI 3		ANI 19	ANI 15	ANI 12	
17	To INV	VCCIO	5V		5V	3.3V	5V	
18	To INV	VCCIO	5V		5V	3.3V	5V	
19	To CPU	GND	GND		GND	GND	GND	
20	To CPU	GND	GND		GND	GND	GND	

### 3.8. DC Link voltage below 22V or Using separate power supply between main and control

The control power is generated from the DC link voltage. But if the DC link voltage is below 22V, it cannot generate the control voltage. If you want to use below 22V for DC link voltage, you need to separate DC link and the control power source.

A) DC link voltage is below 22V. or to separate DC link and the control power source.

- 1) Remove the short socket on JP11 1-2, Install the short socket on JP11 2-3.
- 2) Connect power supply. +15V is for CN2 1pin. And GND is for CN2 2pin.

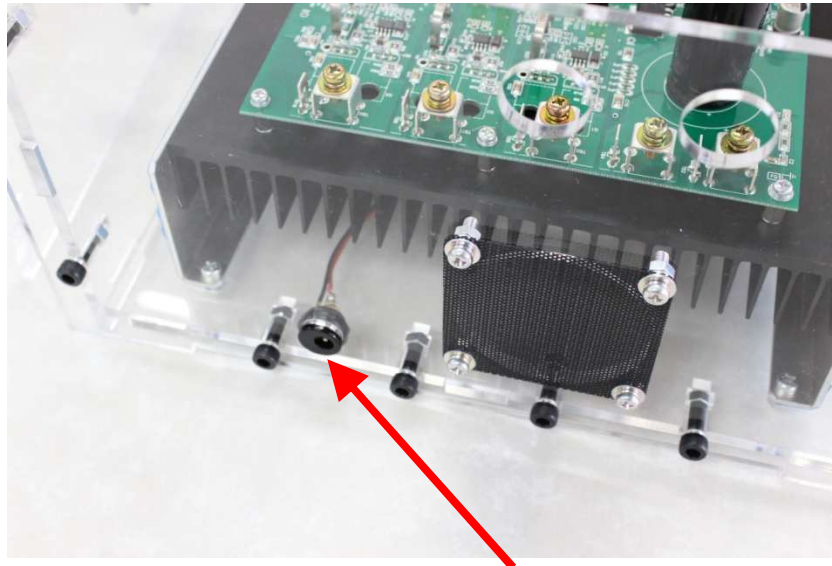
B) The case of to generate control power from the DC link. (Default)

- 1) Install the short socket for JP11 1-2 (Default)
- 2) Remove the connection for CN2.



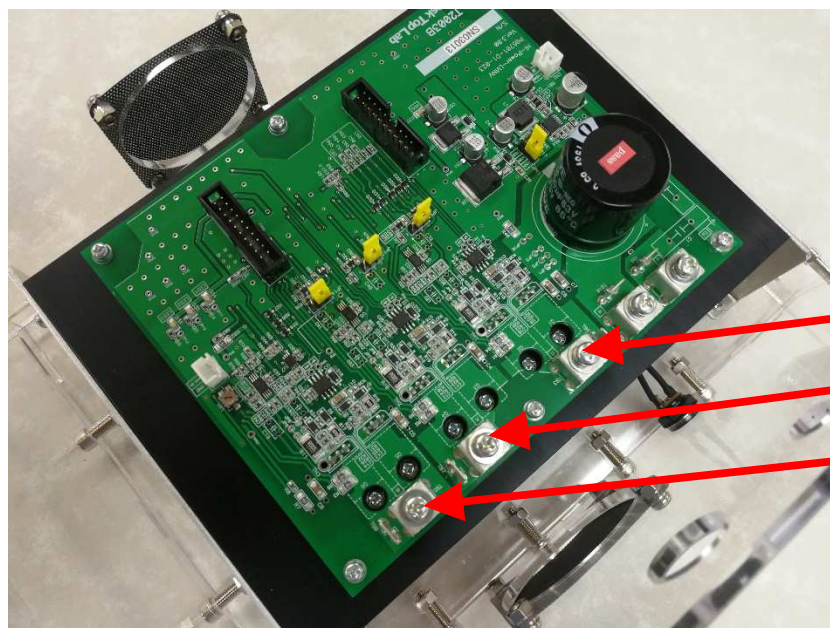
## 4. External connection for T2003C-A

### 4.1. FAN power input



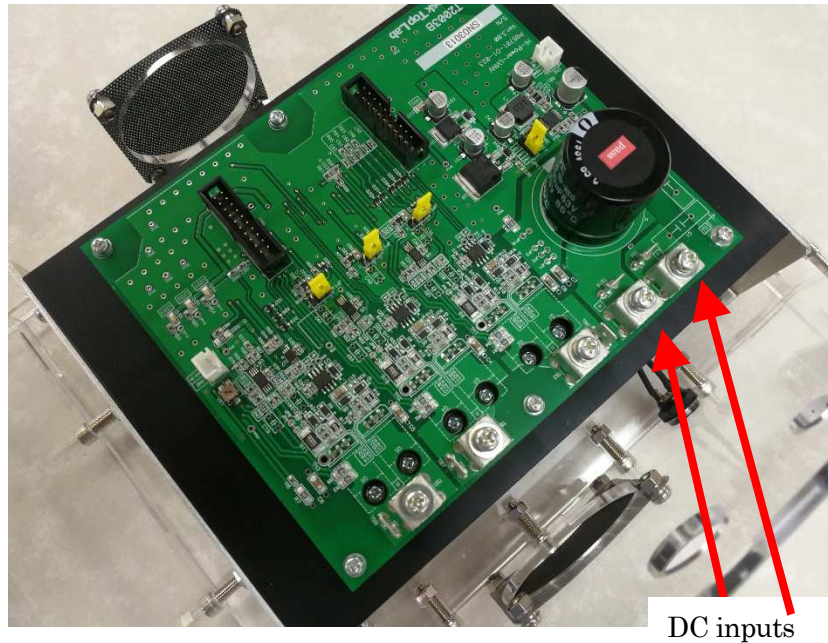
Connect FAN power input connector

### 4.2. Inverter AC output



The absolute maximum rating of the Faston TAB terminal is normally 20A at 2.0mmSQ type. If you want to use larger current than this, please use screw terminals.

### 4.3. Inverter DC input



The absolute maximum rating of the Faston TAB terminal is normally 20A at 2.0mmSQ type. If you want to use larger current than this, please use screw terminals directly.

## 5. Temperature raise value data for T2003C-A

### 5.1. Temperature raise value data

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.

Condition:

T2003 inverter + RX62T 100pin CPU card

Ambient 24°C

Load 3 phase LR load

FAN ON (after 1 hour)

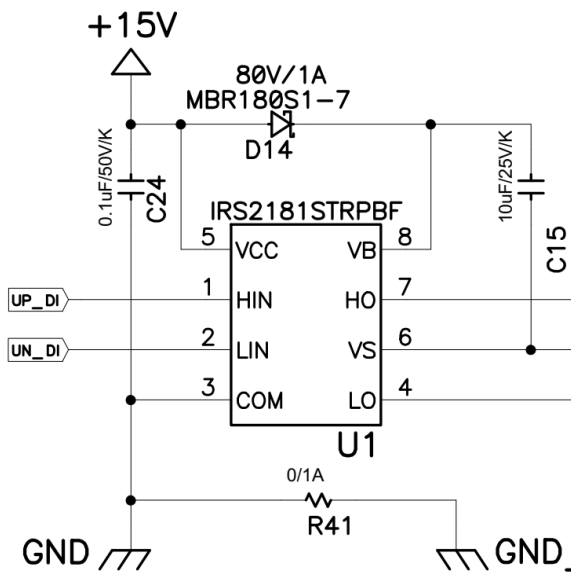
Output power	Output line	Heat sink	Gate driver	Gate resistor
23Apeak	61°C	37°C	62°C	68°C

## 6. Difference between T2003B-A and T2003C-A

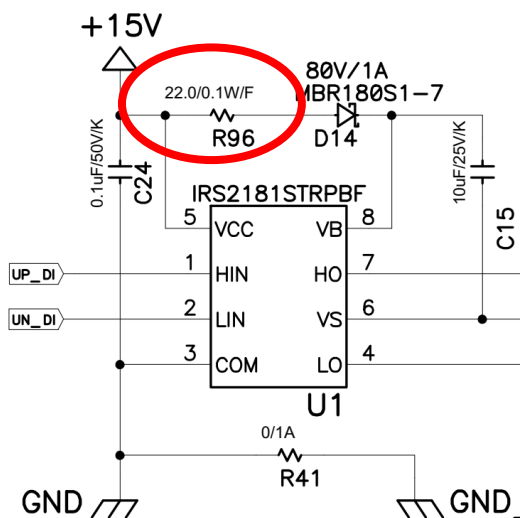
### 6.1. The difference between T2003B-A and T2003C-A

Just three resistors R96, R97, R98 are added to the T2003C-A.

#### 6.1.1. T2003B-A



#### 6.1.2. T2003C-A



## 7. Ordering information

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### 7.1. Order number list

This product has no options

型番	
T2003C-A	

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