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Trial series “T1003”  
200W 300VA Inverter Unit  
Users Manual

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## 1. Introduction

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### 1.1. Introduction

This users' manual is for T1003 High 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 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 RENESAS CPUs.
- \* 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

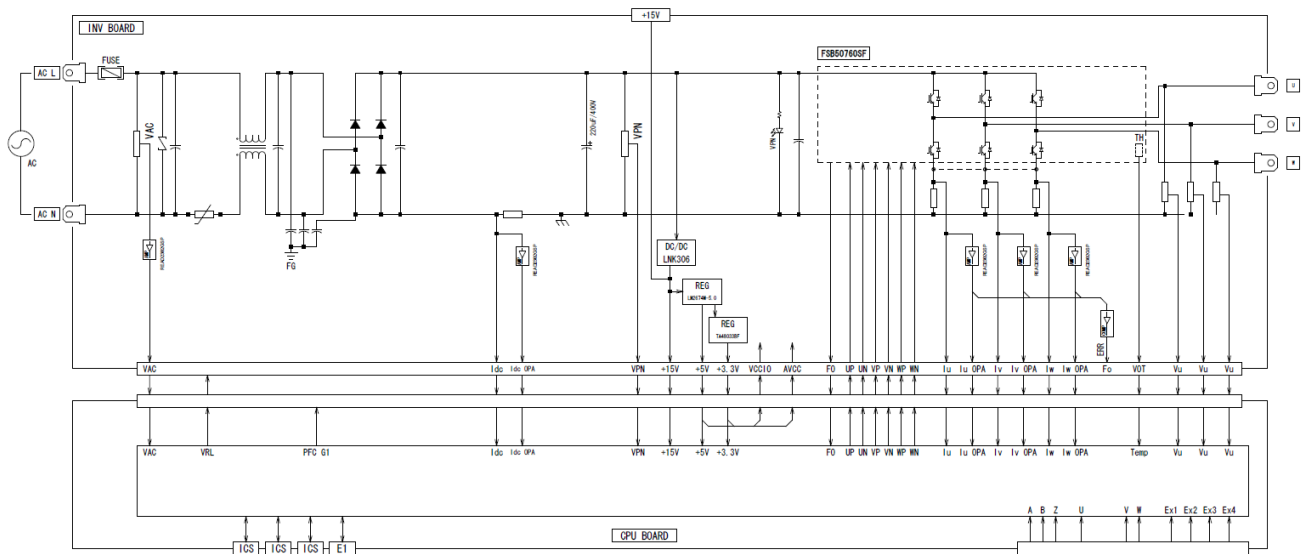


图 2.1. Inverter block diagram

## 2.3. Specification

Item	Specification	Remark
Operation temperature	0°C~35°C	
Operation humidity	Below 90% (No dew condensation)	
Size	281 x 220 x 160 mm	
Weight	2.0kg	
Input voltage range	AC85V~AC265Vrms	
Maximum input power	200W at AC200Vrms input	100W at AC100Vrms input
Rated output power	300VA at AC200Vrms output	At switching frequency 15kHz
Rated output current	AC1A rms at AC200V output	At switching frequency 15kHz
Switching frequency	2kHz~15kHz	This data is example
Deadtime	1.5us	This data is example
Current detection	3 shunt	3 shunts is default. Can be changed to 1 shunt type
Shunt register	100mΩ	
Control power supply	Model T1003-FC FSB50760SF	FairChild
Control power supply	Generated from DC link	Non-isolated
DC link – control circuit isolation	Non-isolated	
Cooling	Force air cooling	
PFC controller	None	
Grid voltage sensor		
DC-BUS current sensor		
DC-BUS voltage sensor		
3phase current sensor		
3phase voltage sensor		
IPM temp 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.



This inverter has in-rush current protection circuits. In-rush current protection circuit is to prevent the destruction of the inverter main circuits and capacitor. If you power on the inverter when the capacitor does not have the electro charge, very large current flows into the DC link capacitor, because the capacitor voltage is almost 0. Once this situation happens, the inverter is sometimes destroyed. So to prevent large current flows, we add the in-rush current protection circuits.



## 3.2. Choice of the current detection circuits

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.

At  $AV_{cc} = 5V$

JP	1-2 Short, 2-3 Open	Equations	1-2 Open, 2-3 Short	Equations
	Outputs		Outputs	
JP2	Iu OPAMP output	$V_{out} = (10 * R * I_{in} + AV_{cc}) / 2$ $I_{in}=5A \rightarrow V_{out}=5V$ $I_{in}=0A \rightarrow V_{out}=2.5V$ $I_{in}=-5A \rightarrow V_{out}=0V$	Iu OPAMP output	$V_{out} = (9 * R * I_{in} + AV_{cc}) / 2$ At 内蔵 OPAGain=5 $I_{in}=5.56A \rightarrow V_{out}=5V$ $I_{in}=0A \rightarrow V_{out}=2.5 V$ $I_{in}=-5.56A \rightarrow V_{out}=0V$
JP3	Iv OPAMP output		Iv OPAMP output	
JP4	Iw OPAMP output		Iw OPAMP output	
JP5	Ipfc OPAMP output		Ipfc OPAMP output	

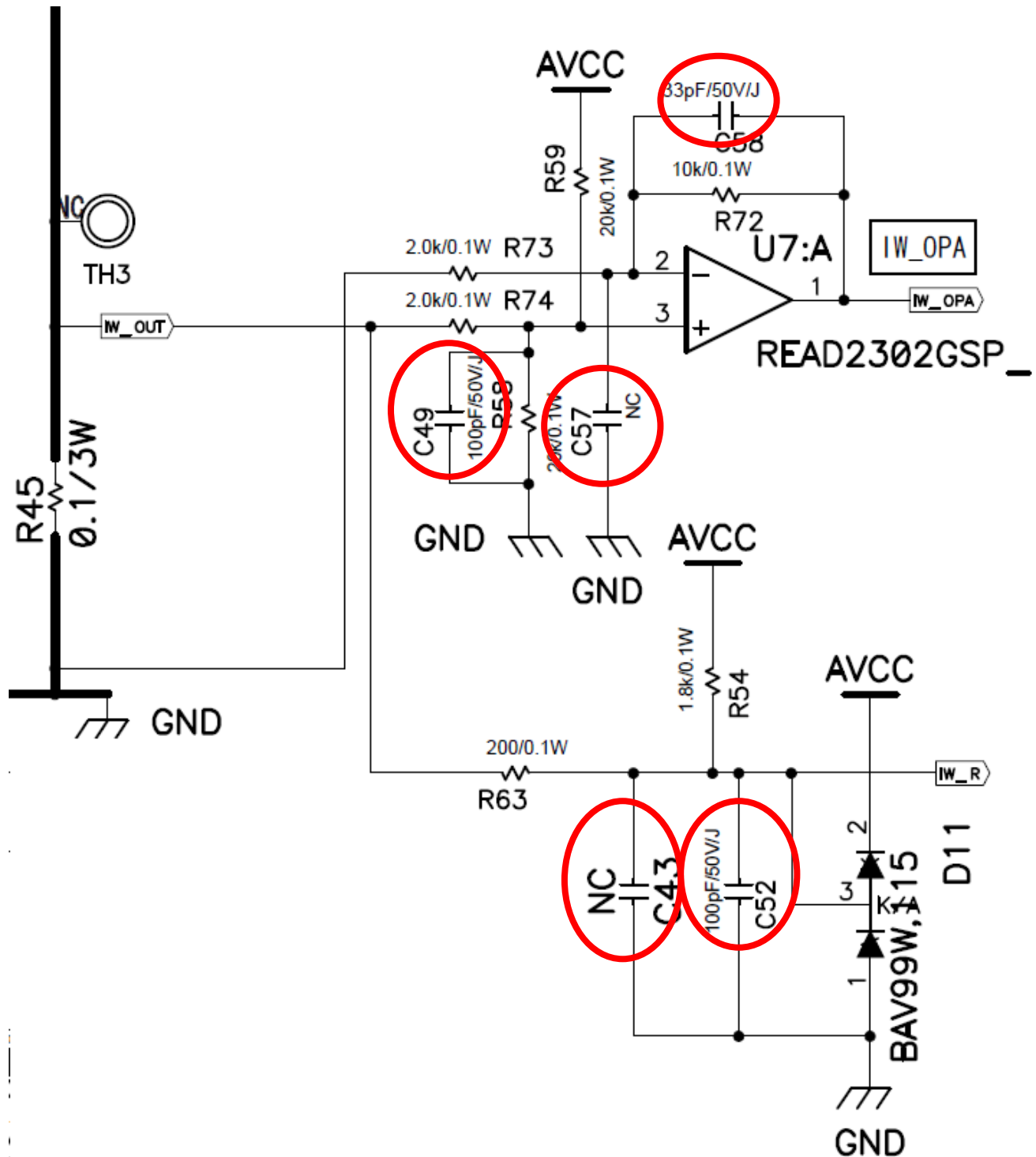
At  $AV_{cc} = 3.3V$

JP	1-2 Short, 2-3 Open	Equations	1-2 Open, 2-3 Short	Equations
	Outputs		Outputs	
JP2	Iu OPAMP output	$V_{out} = (10 * R * I_{in} + AV_{cc}) / 2$ $I_{in}=3.3A \rightarrow V_{out}=3.3V$ $I_{in}=0A \rightarrow V_{out}=1.65V$ $I_{in}=-3.3A \rightarrow V_{out}=0V$	Iu OPAMP output	$V_{out} = (9 * R * I_{in} + AV_{cc}) / 2$ At 内蔵 OPAGain=5 $I_{in}=3.67A \rightarrow V_{out}=3.3V$ $I_{in}=0A \rightarrow V_{out}=1.65 V$ $I_{in}=-3.67A \rightarrow V_{out}=0V$
JP3	Iv OPAMP output		Iv OPAMP output	
JP4	Iw OPAMP output		Iw OPAMP output	
JP5	Ipfc OPAMP output		Ipfc OPAMP output	



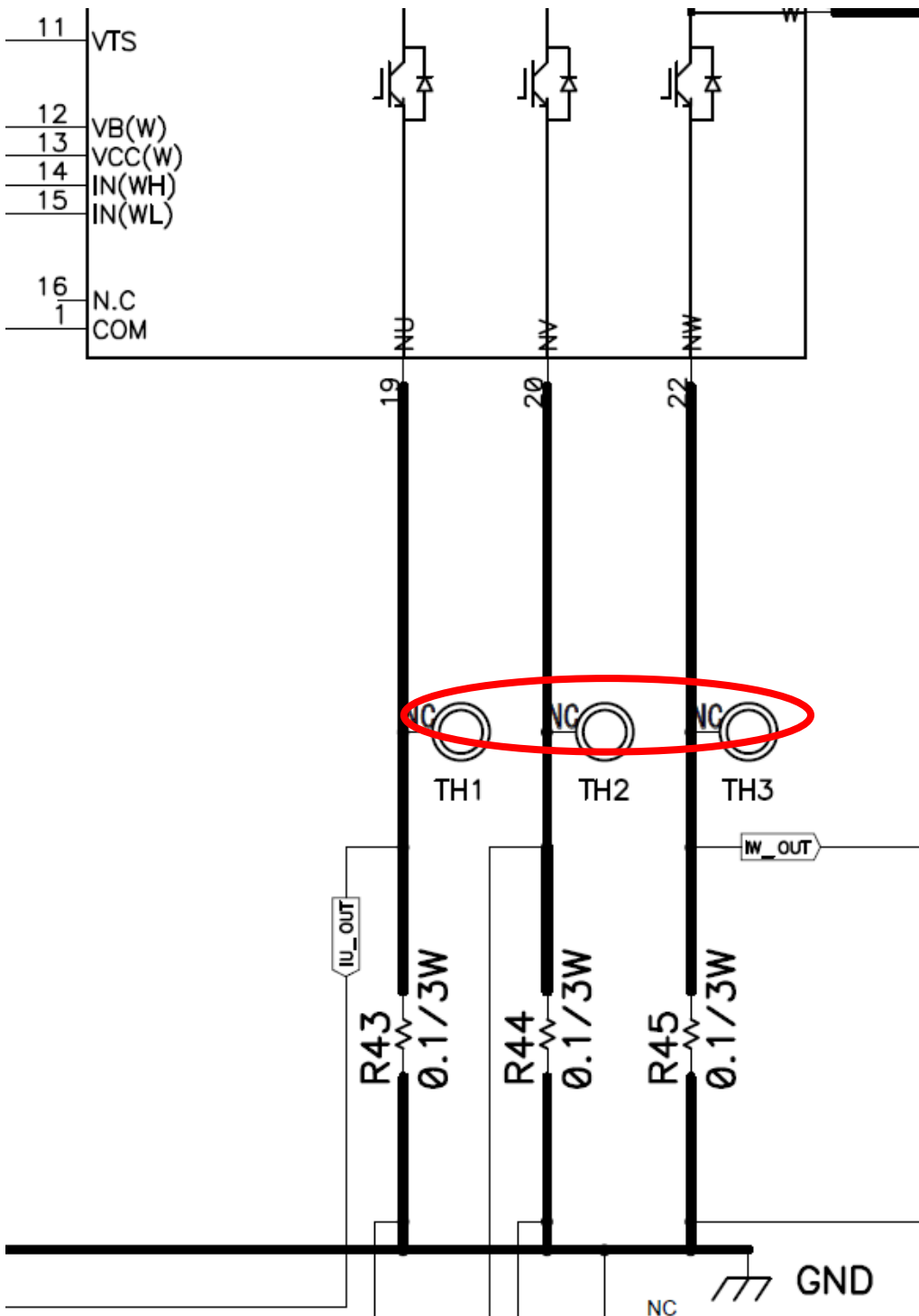
## 3.3. The filter circuits for the current detection

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.



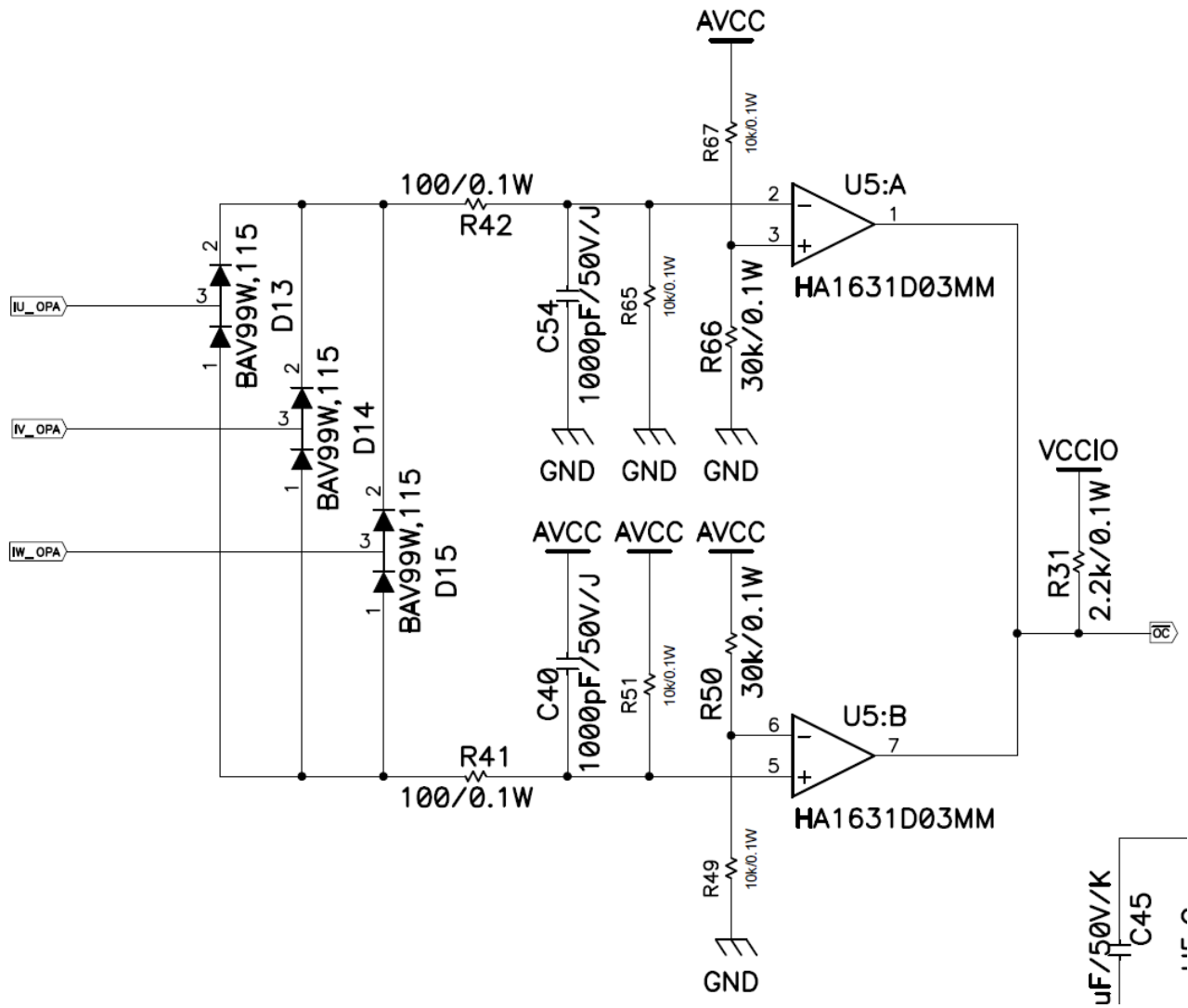
### 3.4. Alterations for one shunt current detection method

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.



## 3.5. 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.



3.6. Voltage detection circuits

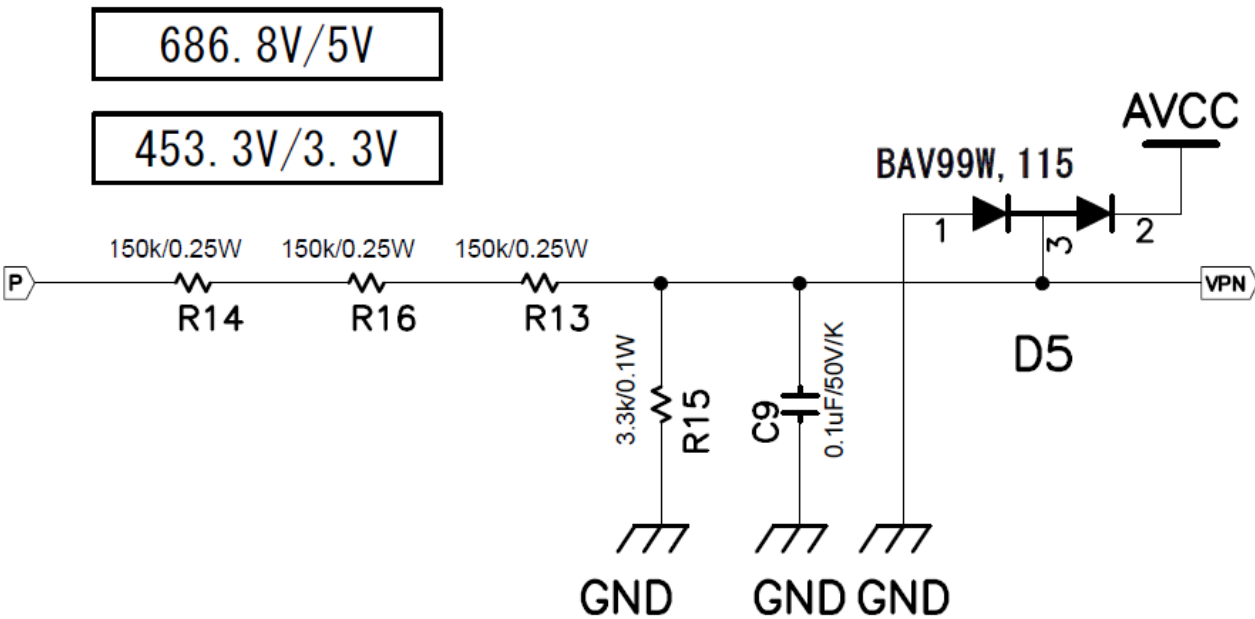
This inverter has four voltage detection circuits.

At AVcc = 5V

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

At AVcc = 3.3V

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



3.7. How to choose CPU voltage

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

## 3.8. Connection information with CPU board

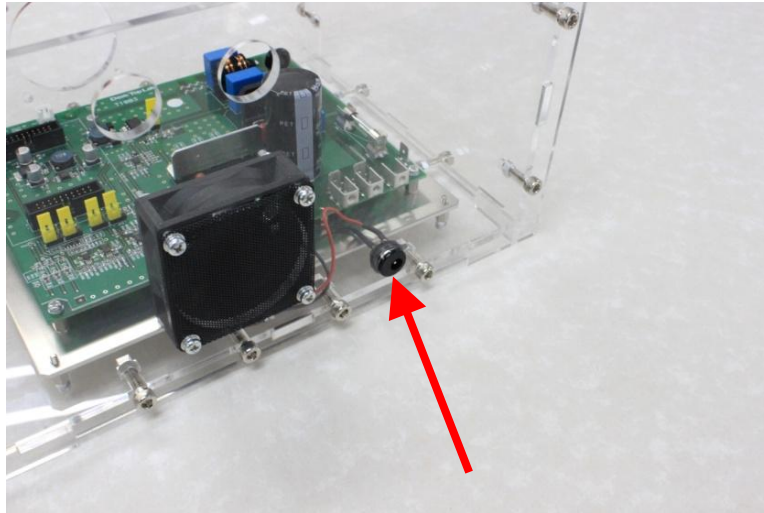
CN-A Digital	Direction	STD Inverter	T5201 RX62T 100pin *1	T5205 RX23T	T5101 RL78/G14 64pin	T5301 RX111 64pin	T5102 RL78/F14 80pin	T5103 RL78/G1F	T5104 RL78G1G
1	To INV	–	PA2	P00	P52	P32	P44	P141	P60
2	To INV	–	PA3	P01	P53	PB0	P47	P140	P61
3	To INV	PFC_G1	PD0	P31	P54	PA1	P41	P04	-
4	To INV	VRL	PB3	PB4	P55	PA0	P42	P55	-
5	To CPU	/FO	P70	P70	P137	PB5	P137	P137	P137
6	To CPU	–							
7	To INV	WN	P76	P76	P10	P55	P30	P10	P10
8	To INV	VN	P75	P75	P11	PB1	P16	P11	P11
9	To INV	UN	P74	P74	P14	PB6	P120	P14	P14
10	To INV	WP	P73	P73	P12	P54	P17	P12	P12
11	To INV	VP	P72	P72	P13	PB3	P15	P13	P13
12	To INV	UP	P71	P71	P15	PB7	P125	P15	P15
13	To CPU		P91	P91	P05	P35	P46	P05	P70
14	To CPU		P92	P92	P06	P31	P45	P06	P17
15	To CPU	5V	5V	5V	5V	5V	5V	5V	5V
16	To CPU	5V	5V	5V	5V	5V	5V	5V	5V
17	To CPU	GND	GND	GND	GND	GND	GND	GND	GND
18	To CPU	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
20	To CPU	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 *1	T5105 RX23T	T5101 RL78/G14 64pin	T5301 RX111 64pin	T5102 RL78/F14 80pin	T5103 RL78/G1F 64pin	T5104 RL78G1G 32pin
1	To INV	AVCC	5V	5V	5V	3.3V	5V	5V	5V
2	To INV	AVCC	5V	5V	5V	3.3V	5V	5V	5V
3	To CPU	-							
4	To CPU	-							
5	To CPU	IU	ANI 000	AN000	ANI 0	ANI 0	ANI 2	ANI2	ANI0
6	To CPU	IV	ANI 001	AN001		ANI 1	ANI 4	-	ANI1
7	To CPU	IW	ANI 002	AN002	ANI 1	ANI 2	ANI 3	ANI3	ANI2
8	To CPU	VPN	ANI 003	AN003	ANI 2	ANI 3	ANI 8	ANI4	ANI3
9	To CPU	TEMP (Vot)	ANI 0	AN007	ANI 7	ANI 4	ANI 10	ANI7	-
10	To CPU	VU	ANI 101	AN004	ANI 3	ANI 6	ANI 5	ANI16	ANI17
11	To CPU	VV	ANI 102	AN005	ANI 4	ANI 8	ANI 6	ANI0	ANI18
12	To CPU	VW	ANI 103	AN006	ANI 5	ANI 11	ANI 7	ANI1	ANI19
13	To CPU	(VAC)	ANI 1	AN016	r ANI 16	ANI 12	ANI 9	ANI5	-
14	To CPU	(IPFC)	ANI 100	(AN017)	r ANI 17	ANI 13	ANI 13	ANI18	-
15	To CPU	(VR1)	ANI 2	AN017	ANI 6	ANI 14	ANI 11	ANI6	ANI10
16	To CPU	(RSV)	ANI 3	-	ANI 19	ANI 15	ANI 12	ANI17 (Yin)	-
17	To INV	VCCIO	5V	5V	5V	3.3V	5V	5V	5V
18	To INV	VCCIO	5V	5V	5V	3.3V	5V	5V	5V
19	To CPU	GND	GND	GND	GND	GND	GND	GND	GND
20	To CPU	GND	GND	GND	GND	GND	GND	GND	GND

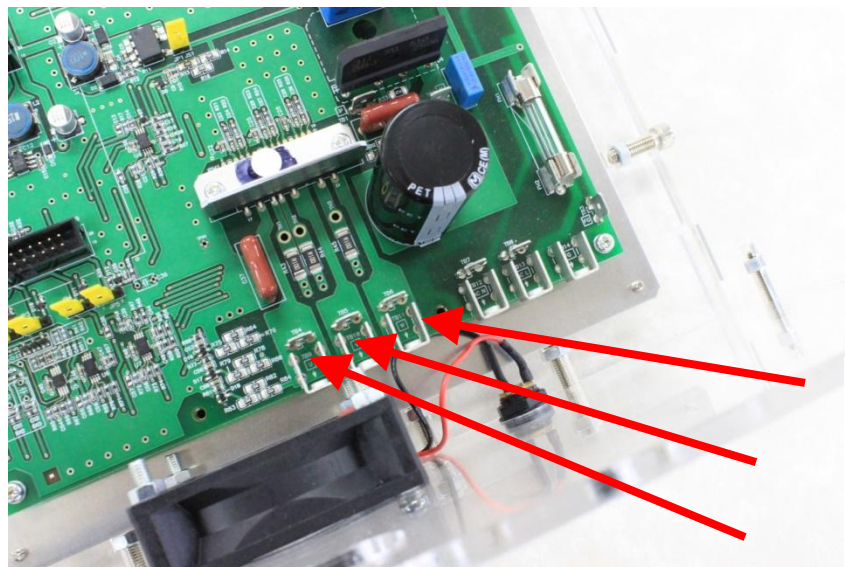
## 4. External connection

### 4.1. FAN power input



Connect FAN power input connector

### 4.2. Inverter AC output

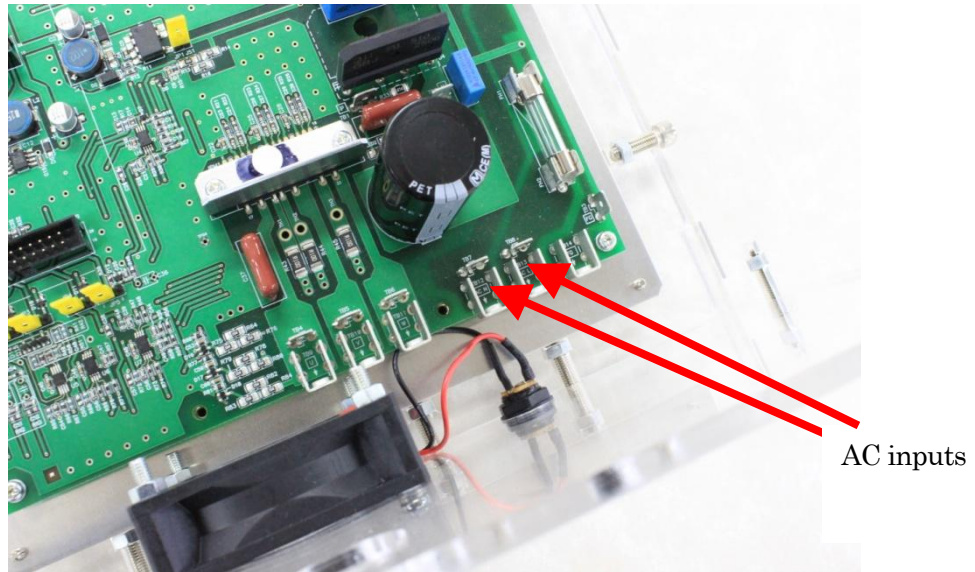


W phase output

V phase output

U phase output

### 4.3. Inverter AC input



## 5. Temperature raise value data for T1003

### 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.

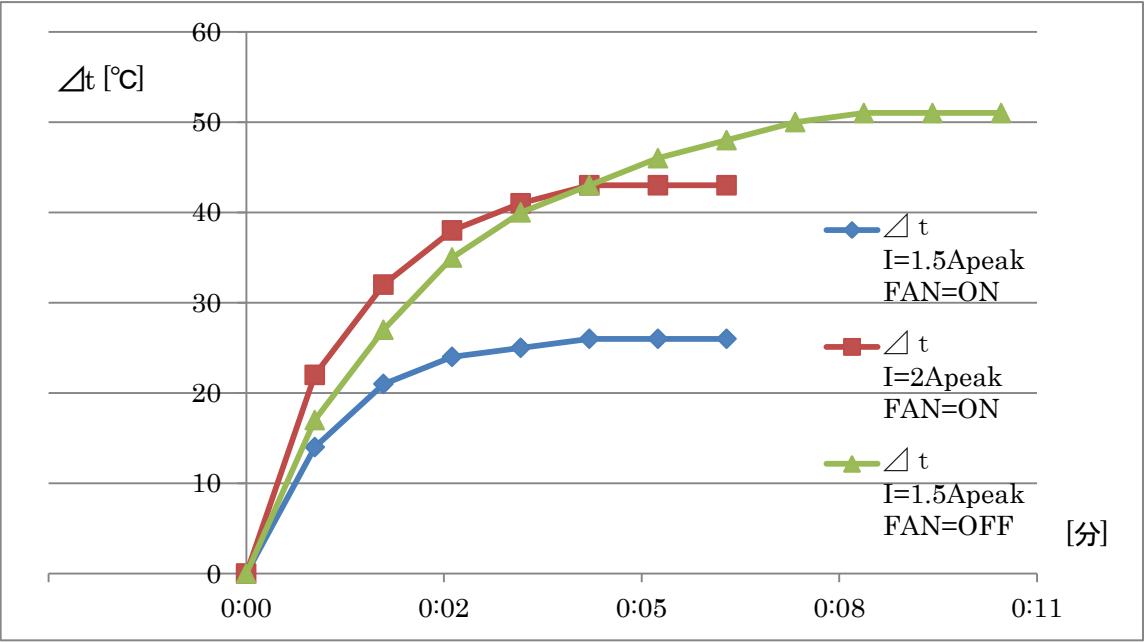
Condition :

T1003 —FC inverter + RX62T 100pin CPU card

Ambient 21°C

Load 3 phase LR Load

Ambient	21℃			気温	21℃			気温	21℃		
Load	誘導機 locked			負荷	誘導機 locked			負荷	誘導機 locked		
Headsink	あり			Headsink	あり			Headsink	あり		
FAN	ON			FAN	ON			FAN	OFF		
Input	DC141V			Input	DC141V			Input	DC141V		
Output g_f4_vref	1.5Apeak 9V			Output g_f4_vref	2Apeak 10.6V			Output g_f4_vref	1.5Apeak 9V		
Time	Time passed [分]	IPM temp [℃]	$\Delta$ t[℃] I=1.5Apeak FAN=ON	Time	Time passed [分]	IPM temp [℃]	$\Delta$ t[℃] I=2Apeak FAN=ON	Time	Time passed [分]	IPM temp [℃]	$\Delta$ t[℃] I=1.5Apeak FAN=OFF
9:58	0:00	21	0	9:41	0:00	21	0	10:10	0:00	21	0
9:59	0:01	35	14	9:42	0:01	43	22	10:11	0:01	38	17
10:00	0:02	42	21	9:43	0:02	53	32	10:12	0:02	48	27
10:01	0:03	45	24	9:44	0:03	59	38	10:13	0:03	56	35
10:02	0:04	46	25	9:45	0:04	62	41	10:14	0:04	61	40
10:03	0:05	47	26	9:46	0:05	64	43	10:15	0:05	64	43
10:04	0:06	47	26	9:47	0:06	64	43	10:16	0:06	67	46
10:05	0:07	47	26	9:48	0:07	64	43	10:17	0:07	69	48
10:06	0:08							10:18	0:08	71	50
10:07	0:09							10:19	0:09	72	51
10:08	0:10							10:20	0:10	72	51
10:09	0:11							10:21	0:11	72	51



## 6. Ordering information

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### 6.1. Order number list

Order number	FAN	Case
T1003	DC	Acryl case

#### OPTION

OPTION	内容
–FC	Use FairChild FSB50760SF for IPM

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