

# Semi-Custom AC-DC Converter with Full Digital Control

**Bellnix®**

**BDG-200 Series**

This product is a semi-custom AC-DC power supply with full digital control. Up to three channels of different type with different output voltage can be selected in arbitrary combination. The PMBus communication function allows to change the output voltage setting, overcurrent protection threshold, turn-on and turn-off sequences, switching frequency, etc., and also to monitor the status of power supply.

## ■ Characteristics

- Power supply with full digital control
- Input voltage: AC85V to 264V
- Output voltage in each of 3 channels can be selected separately.
- Adjustable output voltage range:  $\pm 15\%$
- High efficiency: 87%
- Withstand voltage between I/O: AC 3kV
- UVLO
- Overvoltage protection, overheat protection
- The overcurrent protection threshold can be modified
- Output current can be increased by parallel connection (90% derating required)
- Switching frequency can be modified
- Remnant life prediction function
- Remote control, changing various settings and monitoring the status of power supply is possible using PMBus (serial communication)
- IEC60950 compliant design



## ■ Models and ratings

Table 1

Models BDG Series	Input V Vac	Number of Channels	Output V Vdc	Output I A	Output P W	Efficiency %(typ.)
<b>BDG-200</b>	85 to 264	3	5 (4.25 to 5.75)	14	216 (total of 3 outputs)	87
			12 (10.2 to 13.8)	6		
			24 (20.4 to 27.6)	3		

- Note 1: Output voltage setting range is given in brackets ( ) after the output voltage. The output voltage can be changed using PMBus.  
 Note 2: Each channel of a unit can be selected arbitrarily from the three channels above. Unit cannot be modified after shipment.  
 Note 3: The efficiency is given for output voltage Ch 1: 5V, Ch 2: 12V, Ch 3: 24V, input voltage 200V, rated output, switching frequency 260kHz and normal temperature.  
 Note 4: Depending on ambient temperature, temperature derating may be required.

## ■ Specifications

Table 2

Input voltage range	Refer to Table 1.
Rated input voltage	100VAC
Rated output voltage	5V $\pm 2\%$ (5V output), 12V $\pm 2\%$ (12V output), 24 $\pm 2\%$ (24V output)
Output voltage setting range	Refer to Table 1.
Line regulation	1% max. (for rated output, input voltage range given in Table 1)
Load regulation	2% max. (for rated input/output voltage, load varying from 0 to 100%)
Temperature regulation	2% max. (for rated input/output, operating temperature range -10°C to +50°C)
Integrated regulation	$\pm 3\%$ max. (Including input, load and temperature regulations)
Ripple noise	50mVp-p typ. (5V output), 100mVp-p typ. (12V output), 150mVp-p typ. (24V output) (for rated input/output, normal temperature, measurement frequency bandwidth 20MHz)
Efficiency	87% typ. (for Ch 1: 5V, Ch 2: 12V, Ch 3: 24V, input voltage 200V, rated output, normal temperature)
Overcurrent protection	Triggers at 110% or more of the rated load current (constant current dropping type, automatic restoration)
Output overvoltage protection	Yes (shutdown, restored when input voltage is reapplied)
Under voltage lock out	Yes
Input overcurrent protection	Internal fuse in line and neutral (T6.3A, AC250V)
Overheat protection	Yes (shutdown, restored when input voltage is reapplied)
Remote ON/OFF	Output is ON when between ON/OFF pin and SB_GND pin are open, and OFF when they are short-circuit.
Input OK signal output	When input voltage is normal: Low, when input voltage is too low or too high: open
Device abnormal signal output	Normal output: Low, abnormal: open
Parallel operation	Yes
Output hold time	20ms: output dip not exceeding 90% (for rated input)
Standby power supply	5V $\pm 5\%$ , 0.2A
Remote sensing	Yes
Withstand voltage	Between input and output: AC3000V during 1 minute, between input and FG: AC2500V during 1 minute, between output and FG: AC500V during 1 minute, between outputs: AC500V during 1 minute.
Insulation resistance	Between input and output, between input and FG, between output and FG, between all outputs: not less than 50M $\Omega$ (at DC500V)
Operating temperature range	Operating temperature -10°C to +50°C (Refer to temperature derating on separate sheet)
Storage temperature range	Storage temperature -20°C to +85°C
Humidity range	20 to 95%R.H. (max. wet bulb temperature 35°C without condensation)
Cooling conditions	Natural air cooling, refer to temperature derating on separate sheet
Vibration	5 to 10Hz total amplitude 10mm, 10 to 55Hz acceleration 2G (1 hour in each of 3 directions)
Shock	Acceleration 20G (3 times in each of 3 directions), shock time 11 $\pm$ 5ms
Weight	850g typ.
Outer dimensions	W=195 L=100 H=47 typ. (mm) (excluding protrusions. Refer to section 6-1 for dimension details.)

\* The above specifications are provided for rated values, unless otherwise specified.

## 1. Scope

These specifications apply to the isolated type AC/DC converter of BDG-200 series.

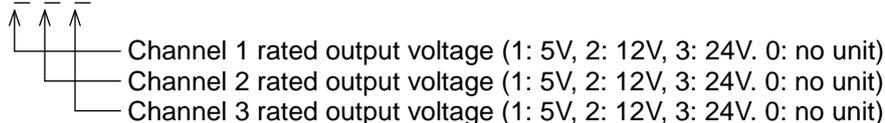
## 2. Models and ratings

Model	Rated input voltage	Rated output (Select any 3 outputs below)	Rated output of the standby power supply	Max output current
BDG-200-### *	AC 100V	5V, 14A(70W)	5V, 0.2A	216W max. (total for 3 outputs, excluding standby power source)
		12V, 6A(72W)		
		24V, 3A(72W)		

Unless otherwise specified in the specifications, rated input, rated output and ambient temperature 25°C±5°C are used.

\* ### indicates the output voltage of each channel.

BDG-200-# # #



Examples:

Channel 1: 5V, channel 2: 12V, channel 3: 24V

BDG-200-123

Channel 1: no unit, channel 2: 12V, channel 3: 12V

BDG-200-022

Also see chapter 14. Model names and configurations.

## 3. Environmental conditions

### 3-1 Temperature range

Operating temperature -10°C to +50°C (temperature over 40°C requires derating)

Storage temperature -20°C to +85°C

### 3-2 Humidity range

Operating humidity 20 to 95% R.H. (max. wet bulb temperature 35°C without condensation)

Storage humidity 20 to 95% R.H. (max. wet bulb temperature 53°C without condensation)

## 4. Specifications and standards

This product is RoHS compliant.

## 4-1 Input characteristics

Item	Specifications and standards	Conditions
Input voltage	AC85 to 264V (rated 100V)	
Input frequency	AC47 to 63Hz (rated 50 / 60Hz)	
Input current	2.6A typ., 2.7A max.	Ch 1: 5V, Ch 2: 12V, Ch 3: 24V, rated input, rated output, switching frequency 260kHz
Power factor	0.9 or higher	Rated input and rated output
Inrush current	20A or lower for rated input	Output power 200W
Leakage current	1mA max.	Input voltage 264V, 60Hz
Input protection	Internal fuse in line and neutral (T6.3A, AC250V)	

## 4-2 Output characteristics and functions

## 4-2-1 Channels 1 to 3

\*1, \*2

Parameter	Specifications and standards			Conditions
	5V output	12V output	24V output	
Rated output voltage	5V	12V	24V	
Output voltage tolerance	±2%			
Output voltage setting range	±15%			Configured via serial communication. Setting range of control target value. The actual output voltage depends on the output voltage deviation setting.
Output current	0 to 14A	0 to 6A	0 to 3A	
Max. output power	70W	72W	72W	
Line regulation	1% max.			Input voltage from 85 to 264V
Load regulation	2% max.			For load regulation in the range 0 to 100%
Temperature regulation	2% max.			For temperature in the range -10 to +50°C
Integrated regulation	±3% max.			Including input voltage, load current and temperature regulation. *3
Ripple noise	50mVp-p typ., 100mVp-p max.	100mVp-p typ., 200mVp-p max.	150mVp-p typ., 300mVp-p max.	BW = 20MHz
Efficiency	87% typ. (depends on combination)			Ch 1: 5V, Ch 2: 12V, Ch 3: 24V, input voltage 200V, rated output, switching frequency 260kHz
Overcurrent protection	Operates at 110% or more of the rated Fixed current drooping type, auto-recovery			Threshold can be changed via serial communication

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Under voltage lock out		Yes Activation voltage: 79V typ. Deactivation voltage: 75V typ.	
Input overvoltage detection		Yes Shutdown, restarts when input voltage is reapplied	
ON/OFF control	For each channel	Yes	Via serial communication
	For all outputs	CN2 ON/OFF pin – SB_GND open: ON short-circuit or Low: OFF	ON/OFF control via serial communication is supported. The control logic shown to the left is used by default. The control logic can be changed using serial communication.
Input OK signal output		Input voltage OK: Low Input voltage too low or too high: Open	
Device abnormal signal output		Output OK : Low Abnormal: Open	
Output overvoltage protection		Shutdown, restarts when input voltage is reapplied	Threshold can be changed using serial communication
Overheat protection		Shutdown, restarts when input voltage is reapplied	
Parallel operation		Yes	Connect the same CS pins N+1 parallel redundant operation requires external OR connection circuit
Switching frequency setting		Yes (260kHz to 300kHz, rated 260kHz)	Configured via serial communication Derating may be required depending on usage conditions
Output hold time		20ms: output dip not exceeding 90%	
Start-up time	Input voltage application	Channels 1 to 3: 1.6s typ., 1.8s max. Standby power: 0.3s typ., 0.5s max.	For turn-on delay 0ms, turn-on rise 100ms
	ON/OFF control	Channels 1 to 3: 0.6s typ.	
Communication function		Yes	PMBus Rev.1.1 compliant
Sequence setting		Yes	Configured via serial communication
Sequence set time tolerance		±2% max.	
Operation monitoring		Yes	Monitoring via serial communication

\*1 Measured using measurement circuit in the chapter 4-6

\*2 Unless otherwise mentioned, measured at rated input, rated output and ambient temperature 25°C±5°C.

\*3 A design value; not confirmed for all values.

## 4-2-2 Standby output

Parameter	Specifications and standards	Conditions
Rated output voltage	5V	
Integrated fluctuation	±5%	Including input, load and temperature regulations
Ripple noise	50mVp-p max.	
Output current	0 to 0.2A	
Overcurrent protection	No	
Short circuit protection	Yes	

\*1 Measured using measurement circuit in the chapter 4-6

\*2 Unless otherwise specified, measured at rated input, rated output and ambient temperature 25°C±5°C.

## 4-3 Withstand voltage, isolation resistance

## 1) Withstand voltage

Between input and output:	AC3000V during 1 minute
Between input and FG:	AC2500V during 1 minute
Between output and FG:	AC500V during 1 minute
Between outputs:	AC500V during 1 minute

## 2) Insulation resistance

Between input and output, input and FG, output and FG:	50MΩ or higher (at DC500V)
Between outputs:	50MΩ or higher (at DC500V)

\* At temperature 25°C±5°C. Humidity conditions according to JEITA RC-9131C.

## 4-4 Safety standards

IEC60950 compliant design

## 4-5 EMC standard

• Conduced Emissions	CISPR pub11 Group I	Class A
• Radiated Emissions	CISPR pub11 Group I	Class A
• Harmonic Currents	IEC61000-3-2	Class A
• Voltage Flicker	IEC61000-3-3	Level 4 Operation standard B
• ESD Immunity	IEC61000-4-2	Level 4 Operation standard B
• Radiated Immunity	IEC61000-4-3	Level 2 Operation standard B
• EFT/Burst	IEC61000-4-4	Level 4 Operation standard B
• Surge	IEC61000-4-5	Class 4 Operation standard B
• Conducted Immunity	IEC61000-4-6	Level 3 Operation standard B
• Dips & Interruptions	IEC61000-4-11	Operation standard B

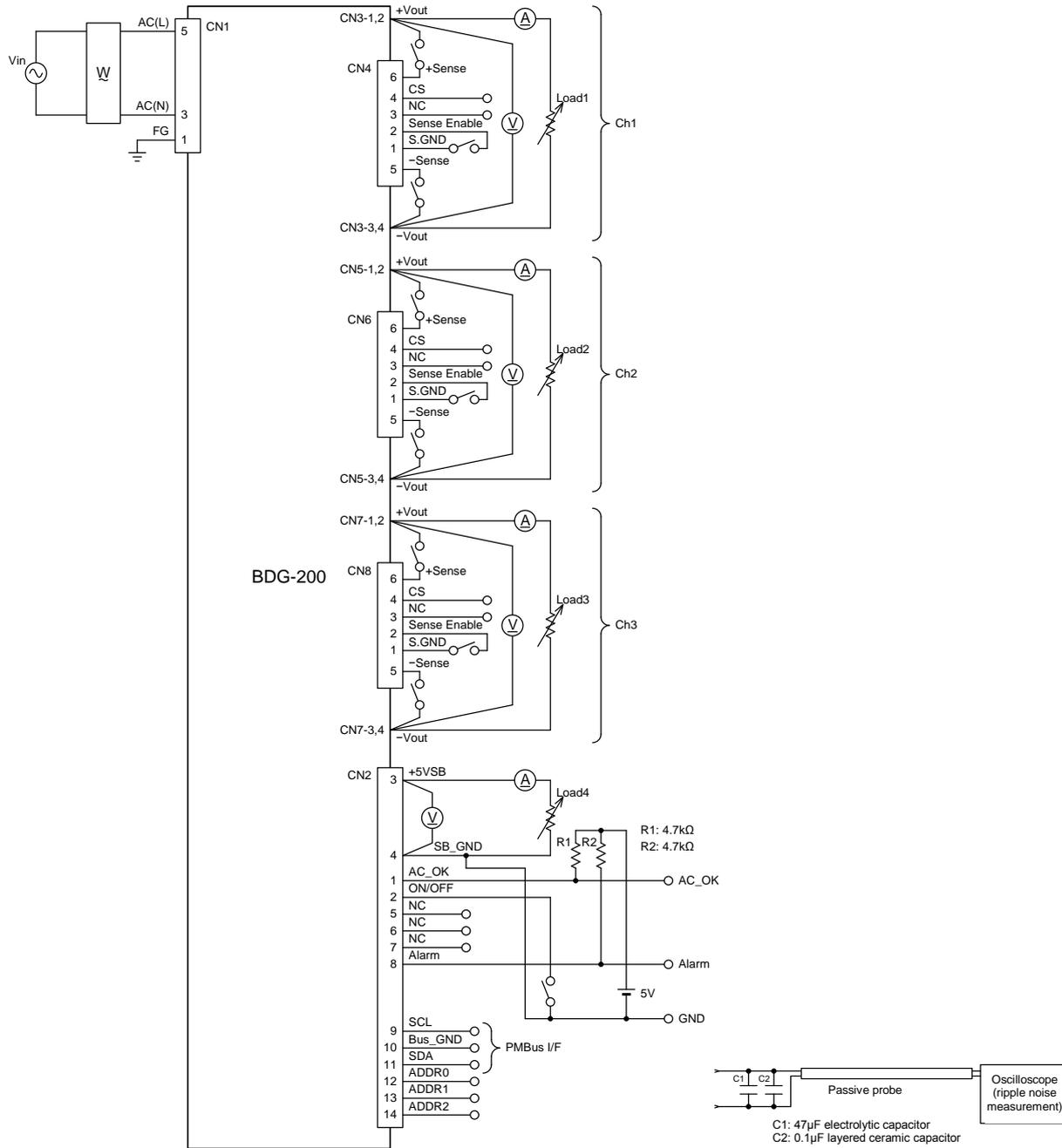
\* This product is designed according to the above standards.

# Semi-Custom AC-DC Converter with Full Digital Control

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## 4-6 Measurement circuit

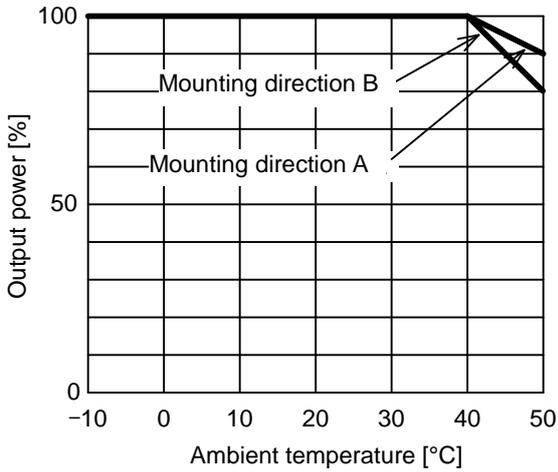


5. Temperature derating

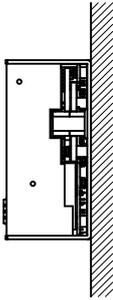
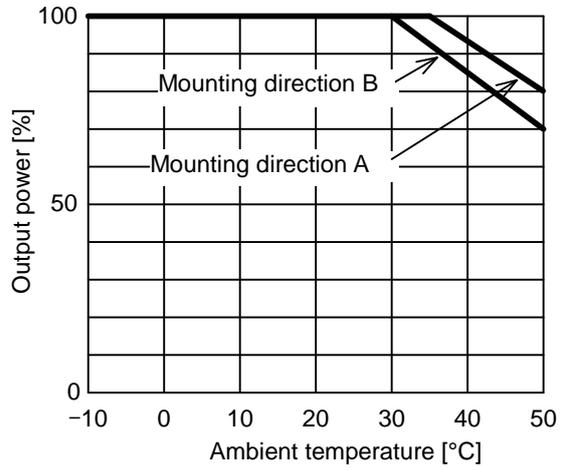
Set the converter in a well-ventilated place and apply derating according to usage environment.

The derating graph below applies to a well-ventilated environment. The device in which the converter is installed should have proper thermal design so that the internal temperature does not exceed temperature conditions of the converter.

Natural air cooling, switching frequency 260kHz



Natural air cooling, switching frequency 300kHz



Mounting direction A



Mounting direction B

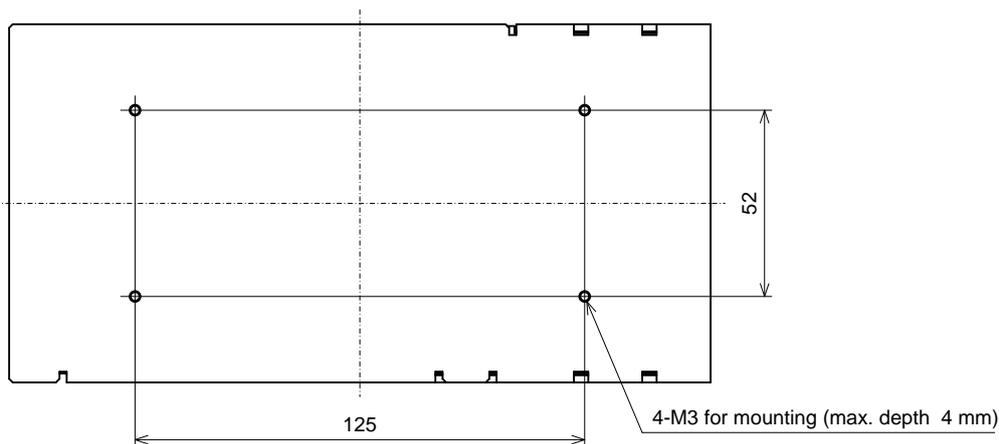
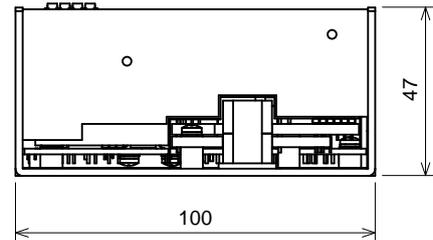
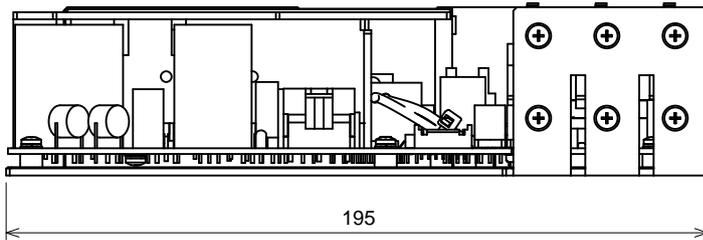
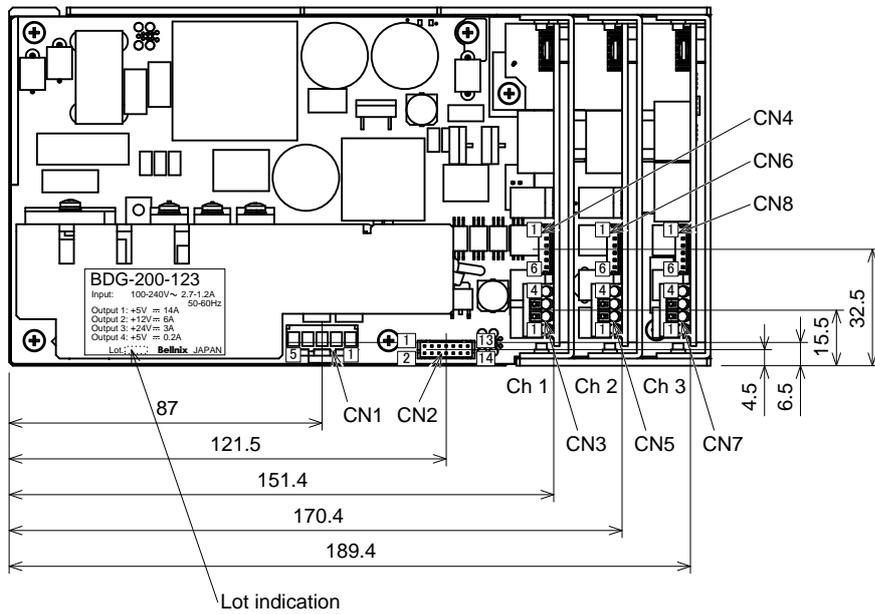
# Semi-Custom AC-DC Converter with Full Digital Control

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## 6. Outer dimensions and pins

### 6-1 Shape and dimensions



Unit: mm  
 Dimensional tolerance:  $\pm 0.5$

## 6-2 Description of pins

## 6-2-1 Global

## 1) Power supply input connector CN1 (B3P5-VH: J.S.T. MFG.Co., LTD.)

Pin	Name	Function
1	FG	Frame ground pin
3	AC(N)	AC power supply pin
5	AC(L)	AC power supply pin

## 2) Control connector CN2 (B14B-PHDSS: made by J.S.T. Connector)

Pin	Name	Function
1	AC_OK	Input OK output pin
2	ON/OFF	Remote ON/OFF control (for all channels) input pin
3	+5VSB	Standby power output pin
4	SB_GND	GND pin for standby power output
5	NC	Do not make other electrical connections.
6	NC	Do not make other electrical connections.
7	NC	Do not make other electrical connections.
8	Alarm	Power failure output pin
9	SCL	Serial communication clock input pin
10	Bus_GND	Serial interface GND pin. Connected to SB_GND pin internally.
11	SDA	Serial interface data input/ output pin
12	ADDR0	Device address setting pin
13	ADDR1	Device address setting pin
14	ADDR2	Device address setting pin

## 6-2-2 For each channel

## 1) Output voltage pins CN3, 5, 7 (0138-5104: DINKLE)

Pin	Name	Function
1	+Vout	(+) Voltage output pin
2	+Vout	(+) Voltage output pin
3	-Vout	(-) voltage output pin
4	-Vout	(-) voltage output pin

Applicable wire: 28 to 16AWG (18AWG recommended)

Wire strip length: 9mm min.

# Semi-Custom AC-DC Converter with Full Digital Control

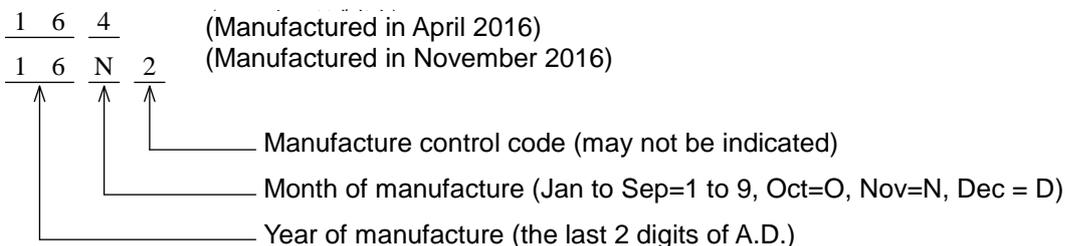
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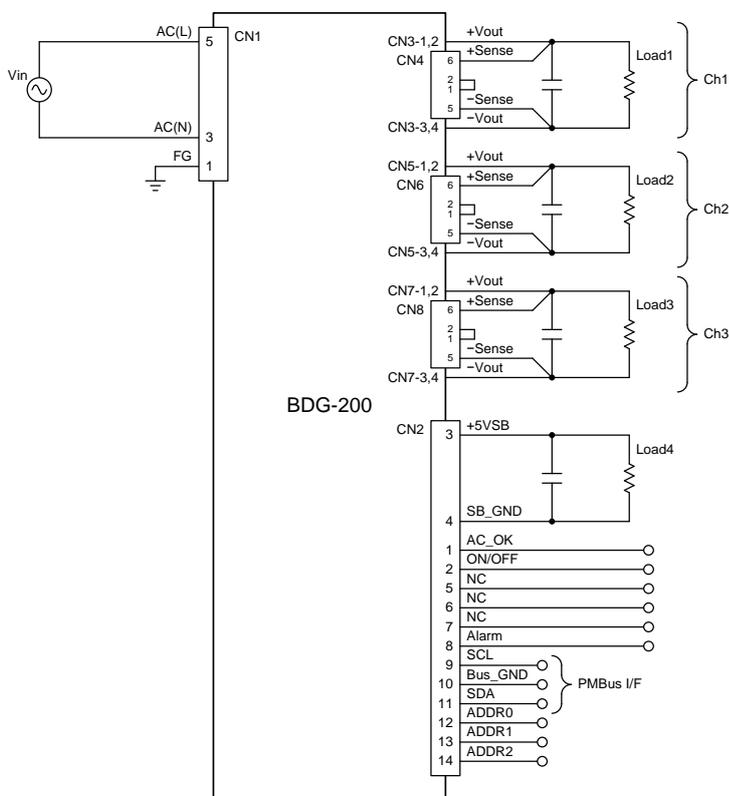
2) Output control connectors CN4, 6, 8 (53254-0670: Molex)

Pin	Name	Function
1	S.GND	Signal GND pin
2	Sense Enable	Remote sensing ON/OFF selection pin Connect to S.GND when using remote sensing Leave open when remote sensing is not used
3	NC	Do not make other electrical connections.
4	CS	Parallel operation input/ output pin
5	-Sense	(-) Remote sensing pin
6	+Sense	(+) Remote sensing pin

6-3 Lot indication



7. Standard connection circuit

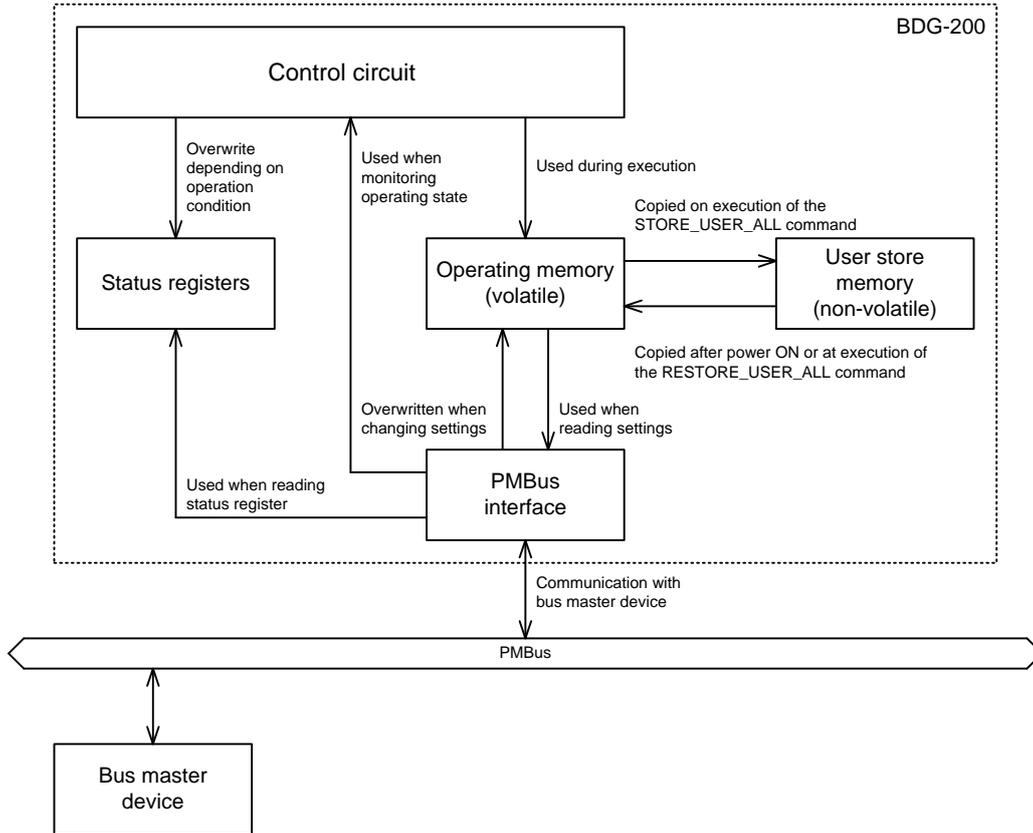


8. Functions

8-1 Digital control

The converter allows setting of output voltage, sequence and other parameters, and also reading of input voltage, output current and other information using serial interface PMBus.

The serial interface allows setting of control target values. Since actual operation is influenced by variation in products, actual and set values will be slightly different.



Digital control conceptual diagram

## 8-1-1 Internal memory

The converter is equipped with volatile operating memory and non-volatile user store memory. Converter settings are stored in the user store memory. The contents of the user store memory is copied into operating memory when power is turned ON.

The control circuit of this converter operates using contents of the operating memory. When settings are changed using serial communication, they are written into the operating memory. Because the operating memory is volatile, the modified settings will be lost when power is turned OFF.

To change settings used when power is turned ON, they need to be saved in the non-volatile user store memory by STORE\_USER\_ALL command after the operating memory is overwritten.

RESTORE\_USER\_ALL command can be used to replace the contents of the operating memory with the data stored in the user store memory (revert to the settings when the previous STORE\_USER\_ALL command was executed).

Settings made by the following commands can be stored and restored using STORE\_USER\_ALL and RESTORE\_USER\_ALL commands.

- ON\_OFF\_CONFIG
- VOUT\_COMMAND
- VOUT\_TRIM
- FREQUENCY\_SWITCH
- VOUT\_OV\_FAULT\_LIMIT
- IOUT\_OC\_FAULT\_LIMIT
- TON\_DELAY
- TON\_RISE
- TOFF\_DELAY

Setting items	PMBus command
Store settings	STORE_USER_ALL
Restore settings	RESTORE_USER_ALL

## 8-2 Output voltage setting

The converter allows setting of the output voltage using serial communication within the range  $\pm 15\%$  of the rated voltage. Since it is not possible to change the output voltage due to potentiometer etc., when output voltage other than default setting is required, the output voltage setting needs to be changed via serial communication.

Setting items	PMBus command	Setting range	Setting resolution	Default setting
Output voltage setting	VOUT_COMMAND	Rated voltage $\pm 15\%$	5V (with remote sensing): App. 9mV 5V (without remote sensing): App. 8mV 12V (with remote sensing): App. 21mV 12V (without remote sensing): App. 19mV 24V (with remote sensing): App. 36mV 24V (without remote sensing): App. 37mV	Rated voltage

### 8-3 Output voltage trimming function

The output voltage trimming function can be used to increase or decrease the output voltage.

The set value of the output voltage trimming function can be modified using serial communication.

Setting items	PMBus command	Setting range	Setting resolution	Default setting
Output voltage trimming setting	VOUT_TRIM	5V: -100 to 100 mV 12V: -240 to 240 mV 24V: -480 to 480 mV	Same as output voltage setting resolution	0mV

### 8-4 Remote sensing function

The remote sensing function can be used to obtain good load regulation characteristics on the load side. The sensing line is a part of the feedback loop, and since it has very high sensitivity, careful attention is required when making routing. +Sense and -Sense wires should be routed to the load as a twisted pair.

When using this function, the output voltage (voltage between +Vout and -Vout pins) will become higher than voltage in the output voltage control point (between +Sense and -Sense pins), so make sure that the output voltage does not exceed the allowable output voltage range. Also make sure that the output power does not exceed the rated maximum output power.

When using this function, connect Sense Enable pin to S.GND pin. Connect Sense Enable and S. GND pins at the base of the connector; do not extend these wires.

If this function is not used, leave +Sense, -Sense, Sense Enable and S.GND pins open.

### 8-5 ON/OFF control function

This function can be used to turn output voltage ON and OFF without connecting or disconnecting the input voltage. This converter supports ON/OFF control for all output channels at the same time, as well as individual ON/OFF control for each channel.

The ON/OFF control for all output channels at the same time can be done by two methods: using ON/OFF pin and serial communication.

Individual ON/OFF control for each output channel can be performed only by serial communication.

It is possible to enable and disable ON/OFF control by ON/OFF pin and by serial communication separately. ON/OFF control can be enabled and disabled by serial communication. By default, the ON/OFF control by the ON/OFF pin is set enabled.

ON/OFF control command has a high OFF priority. When ON/OFF control by the ON/OFF pin and by serial communication are both enabled, the output will not turn ON until both controls are set to ON.

ON/OFF control of the standby power is not supported.

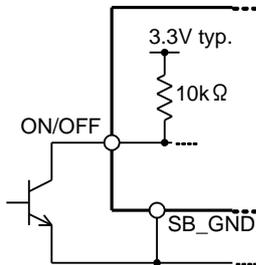
#### 8-5-1 ON/OFF control by the ON/OFF pin

All outputs can be turned ON or OFF by opening or short-circuiting between ON/OFF pin and SB\_GND pin.

The ON/OFF pin is connected internally to 3.3V typ. power supply via 10kΩ resistor.

The control logic of the ON/OFF pin can be set to positive logic (output ON when open) or negative logic (output OFF when open). The control logic of the ON/OFF pin can be set by serial communication. By default it is set to active high.

Between ON/OFF pin and SB_GND pin	Active high (default setting)	Active low
Open	Output ON	Output OFF
Short-circuit (0 to 0.6V, 0.5mA max.)	Output OFF	Output ON



Note: Avoid chattering on the ON/OFF pin. The chattering may cause malfunction of internal circuits.

When turning the output OFF using the ON/OFF pin, it is possible to set whether to stop by applying the turn-off sequence (whether to apply the turn-off delay or not). The stop method can be selected by serial communication (ON\_OFF\_CONFIG command). By default it is set to stop without applying the turn-off sequence.

#### 8-5-2 ON/OFF control by serial communication

Output voltage can be turned ON and OFF by serial communication.

When turning the output OFF by serial communication, it is possible to set whether to apply the turn-off sequence to stop or not.

The serial communication can be used to turn ON/OFF all channels simultaneously or individually each channels.

Setting item	PMBus command	Default setting
ON/OFF control via serial communication	OPERATION	Output OFF*
ON/OFF control configuration	ON_OFF_CONFIG	ON/OFF control by the ON/OFF pin Enabled ON/OFF control via serial communication DISABLED ON/OFF pin active high When turning output OFF by ON/OFF pin the turn-off delay sequence is NOT USED

\* When power is applied, it will be initialize to output OFF, which is the default setting. This setting cannot be stored in the user store memory.

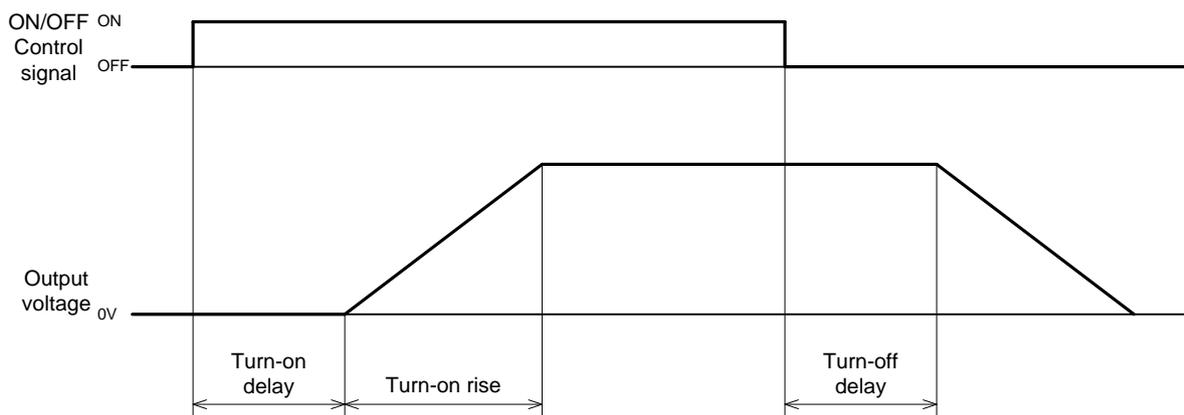
## 8-6 Sequence setting function

The following items can be set by the sequence setting function.

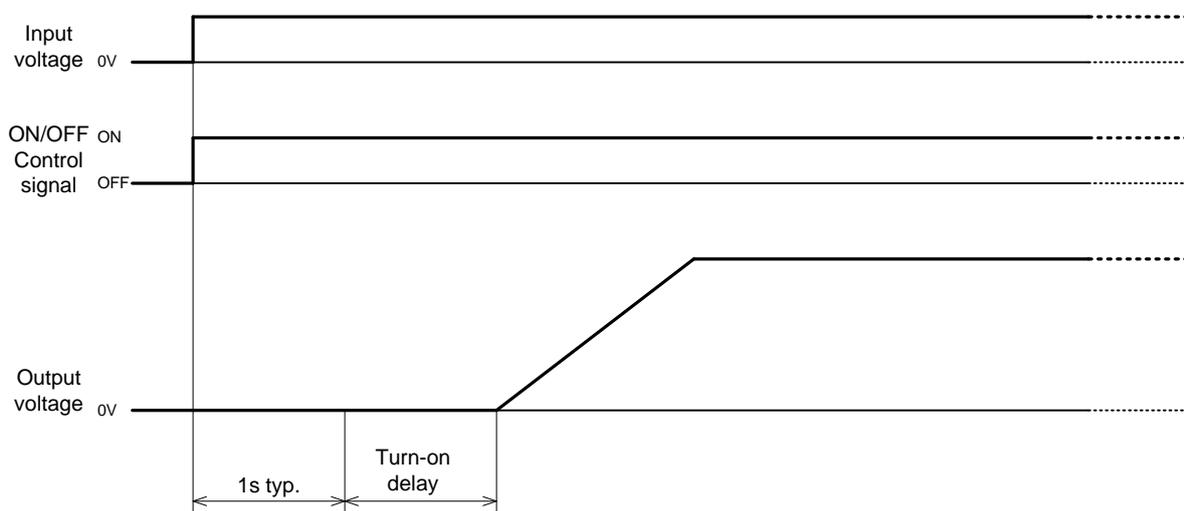
- Turn-on Delay
- Turn-on Rise
- Turn-off Delay

The turn-on delay is the time from when the ON command is issued by ON/OFF control (ON/OFF pin or serial communication) until the output voltage starts to rise (see figure below).

The turn-off delay is the time from when the OFF command is issued by ON/OFF control (ON/OFF pin or serial communication) until the output voltage starts to fall (see figure below).



When input voltage is applied, there is a waiting time of 1s typ. until the start of turn-on sequence (see figure below).



The setting of the sequence function can be modified using serial communication.

However, depending on the load capacitance, the charging time may be insufficient, and it may not start up within the set time. If the charging time is insufficient, the overcurrent protection may operate.

Also, during parallel operation, the rise may be stepwise and may not rise completely within the set time.

Setting items	PMBus command	Setting range	Setting resolution	Default setting
Turn-on delay	TON_DELAY	0 to 5000ms	1ms	0ms
Turn-on rise	TON_RISE	5 to 1000ms	1ms	100ms
Turn-off delay	TOFF_DELAY	0 to 500ms	1ms	0ms

When all output channels are turned ON at the same time by ON/OFF pin or via serial communication, there will be an additional delay of 500ms in actual operation, even if the turn-on delay setting is less than 500ms.

When turning ON all output channels at the same time by applying input voltage, there is a waiting time of 1s typ. before the turn-on delay (see previous page). Even if the turn-on delay setting is less than 500ms, there will be an additional delay of 500ms in actual operation.

When all output channels are turned OFF at the same time by ON/OFF pin or via serial communication, there will be an additional delay of 20ms in actual operation, even if the turn-off delay setting is less than 20ms.

When output channels are turned ON/OFF individually via serial communication, there will be an additional delay of 1ms in actual operation, even if the turn-on or turn-off delay setting is less than 1ms.

The turn-off delay setting is not applied in the following cases.

- When turning output OFF via serial communication with turn-off sequence disabled
- When turning output OFF by ON/OFF pin with sequence disabled for the ON/OFF pin control
- When output is turned off by the protection function operation

## 8-7 Operation monitoring

Information about input voltage, output voltage, output current, device temperature, total operating time and estimated lifetime of the converter can be obtained via serial communication.

The converter contains 8 following status registers: STATUS\_BYTE, STATUS\_WORD, STATUS\_VOUT, STATUS\_IOUT, STATUS\_INPUT, STATUS\_TEMPERATURE, STATUS\_CML and STATUS\_MFR\_SPECIFIC. By checking contents of status registers, it is possible to determine the error status of this product.

The status registers are set when protection function operates, and contents of the registers are retained even if the cause of the register setting is removed. However, the status of under voltage lock out is cleared automatically. The status registers can be cleared under any of the following conditions.

- Executing CLEAR\_FAULTS command
- Reapplying input voltage

Bits of the status register linked to the protection function that latch stops are not cleared even if the CLEAR\_FAULTS command is executed.

When reapplying the input voltage, keep input in OFF state for more than 30 seconds.

The contents of each register can be read via serial communication. For detailed information about contents of each register, refer to sections describing registers reading instructions.

Item	PMBus command
Input voltage monitoring	READ_VIN
Output voltage monitoring	READ_VOUT
Output current monitoring	READ_IOUT
Device temperature monitoring	READ_TEMPERATURE_1, READ_TEMPERATURE_2
Total operating time	READ_OPERATING_TIME
Estimated life	READ_ESTIMATED_LIFE
STATUS_BYTE register	STATUS_BYTE
STATUS_WORD register	STATUS_WORD
STATUS_VOUT register	STATUS_VOUT
STATUS_IOUT register	STATUS_IOUT
STATUS_INPUT register	STATUS_INPUT
STATUS_TEMPERATURE register	STATUS_TEMPERATURE
STATUS_CML register	STATUS_CML
STATUS_MFR_SPECIFIC register	STATUS_MFR_SPECIFIC

#### 8-8 Status register history function

This converter can save values of the status registers in nonvolatile memory when the under voltage lock out function is operating. The saved data can be read via serial communication.

Item	PMBus command
STATUS_BYTE register history	STATUS_BYTE_HISTORY
STATUS_WORD register history	STATUS_WORD_HISTORY
STATUS_VOUT register history	STATUS_VOUT_HISTORY
STATUS_IOUT register history	STATUS_IOUT_HISTORY
STATUS_INPUT register history	STATUS_INPUT_HISTORY
STATUS_TEMPERATURE register history	STATUS_TEMPERATURE_HISTORY
STATUS_CML register history	STATUS_CML_HISTORY
STATUS_MFR_SPECIFIC register history	STATUS_MFR_SPECIFIC_HISTORY

Since the status register history is saved when the under voltage lock out function is operating, the bit indicating the under voltage condition is always set.

Since the status register history is overwritten each time the under voltage lock out function operates, it is not possible to obtain register values other than those that were in the status register at the time of the latest operation of the under voltage lock out function.

#### 8-9 Under voltage lock out

The converter is equipped with under voltage lock out (UVLO) function preventing malfunction when input voltage is low. When the input voltage exceeds the activation voltage (79V typ.), the converter starts switching operation. If the input voltage falls below the deactivation voltage (75V typ.), the switching operation stops.

## 8-10 Input overvoltage detection

When the input voltage exceeds the threshold of the input overvoltage protection function, the converter stops switching operation. Because internal parts are not protected, they can be damaged by excessive input voltage.

Since this function is a latch-type function, it does not restart automatically. To release the latched condition, reapply the input voltage. When reapplying the input voltage, keep input in OFF state for more than 30 seconds.

## 8-11 Output overvoltage protection

When the output voltage (the voltage between +Vout and -Vout pins) exceeds the threshold of the output overvoltage protection function, the converter stops switching operation. However, the function may not activate if overvoltage is caused by damaged unit.

When the remote sensing function is enabled, the voltage at output voltage control point (between +Sense and -Sense pins) and overvoltage detection point (between +Vout and -Vout pins) will be different. So be sure to consider voltage drop caused by wiring, when setting the protection threshold.

Since this function is a latch-type function, it does not restart automatically. To release the latched condition, reapply the input voltage. When reapplying the input voltage, keep input in OFF state for more than 30 seconds.

The operation threshold of the output overvoltage function can be configured via serial communication.

Setting items	PMBus command	Setting range	Setting resolution	Default setting
Output overvoltage protection threshold	VOUT_OV_FA ULT_LIMIT	5V: 0 to 6.75V	5V (with remote sensing): App. 7 mV	5V: 6.75V
		12V: 0 to 16.2V	5V (without remote sensing): App. 8mV	12V: 16.2V
		24V: 0 to 32.4V	12V (with remote sensing): App. 18 mV	24V: 32.4V
			12V (without remote sensing): App. 20 mV	
			24V (with remote sensing): App. 33mV	
			23V (without remote sensing): App. 34 mV	

## 8-12 Output overcurrent protection

When the output overcurrent protection function operates, the output voltage is decreased to limit the output current. When the overcurrent condition is canceled, the output voltage will recover automatically.

The operation threshold of the output overcurrent function can be configured via serial communication.

Setting items	PMBus command	Setting range	Setting resolution	Default setting
Output overcurrent protection threshold	IOUT_OC_FAULT_LIMIT	5V: 7 to 16.1A	5V: App. 26mA	5V: 16.1A
		12V: 3 to 6.9A	12V: App. 12 mA	12V: 6.9A
		24V: 1.5 to 3.7A	24V: App. 6 mA	24V: 3.7A

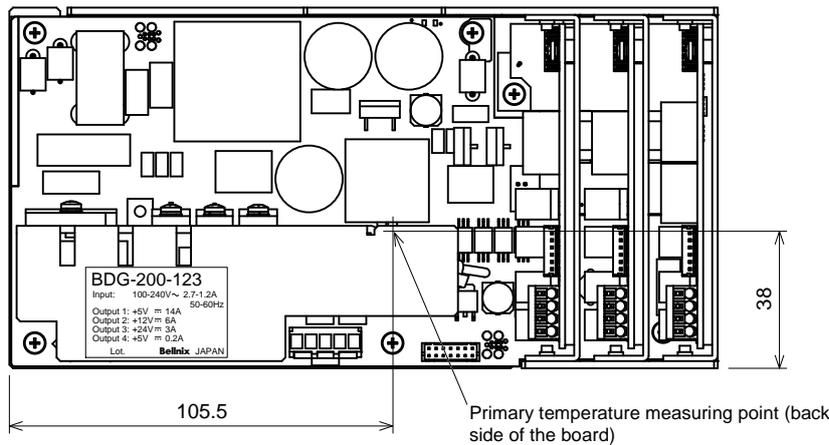
### 8-13 Overheat protection

When measured temperature of the converter exceeds the overheat protection threshold, the overheat protection function operates, stopping the switching operation.

Since this function is a latch-type function, it does not restart automatically. To release the latched condition, reapply the input voltage. When reapplying the input voltage, keep input in OFF state for more than 30 seconds.

There is one temperature sensor mounted on the primary side (place shown in the figure below), and there is also one sensor for each output channel.

The temperature at which the overheat protection function triggers is not the maximum operating temperature. Therefore, even if this temperature is below the overhead protection threshold, do not use the converter at temperatures outside the derating range shown in chapter 5.



### 8-14 Parallel operation

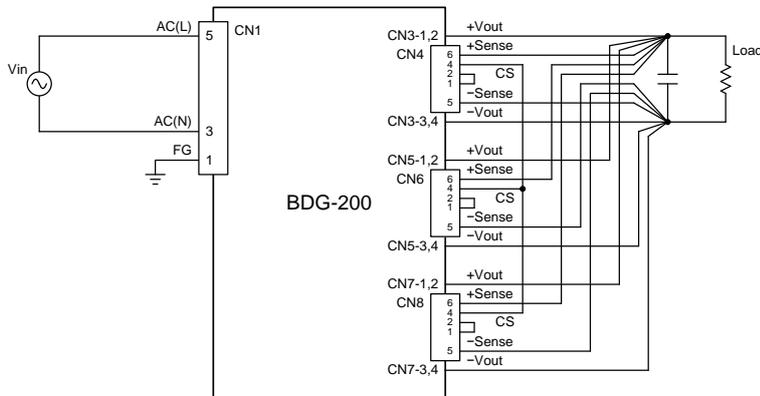
Parallel operation can be performed by connecting the +Vout pins and -Vout pins of each channel to each other, and then connecting the CS pins to each other. Always use the remote sensing function during parallel operation.

Set the same output voltage settings for all output channels used in parallel.

The wiring of +Vout and -Vout pins should have the same length for all output channels.

Load derating is required during parallel operation. Load factor should not exceed 90%.

#### Connection example



## 8-15 Switching frequency setting

Using this function, the switching frequency can be set in the range from 260 kHz to 300 kHz.

The switching frequency can be set using serial communication. Settings can be changed only when all output channels are OFF.

Setting items	PMBus command	Setting range	Setting resolution	Default setting
Switching frequency	FREQUENCY_SWITCH	260 to 300kHz	1kHz	260kHz

## 8-16 Input OK signal (AC\_OK) output

The Input OK signal output can be used to notify the state of input voltage.

When the input voltage exceeds the operation start voltage, this output is in Low state. When the input voltage falls below the operation stop voltage, this output is open (high impedance).

It also becomes open (high impedance) when input overvoltage detection function operates. After the input overvoltage detection function is triggered, this output remains open even if the input voltage is reduced below the threshold.

Applicable voltage: 30V max.

Output Low level: 0.4V max. (sink current 20mA max.)

## 8-17 Device abnormal signal (Alarm) output

The Device abnormal signal output can be used to notify if there are any device failures. The device abnormal signal is synchronized with status registers.

Normally Low, when at least one bit of the status register is set, this output becomes open (high impedance).

Applicable voltage: 30V max.

Output Low level: 0.4V max. (sink current 20mA max.)

## 9. Serial interface

## 9-1 Definitions of symbols and terms

9. The symbols and terms used in this chapter are defined as follows.

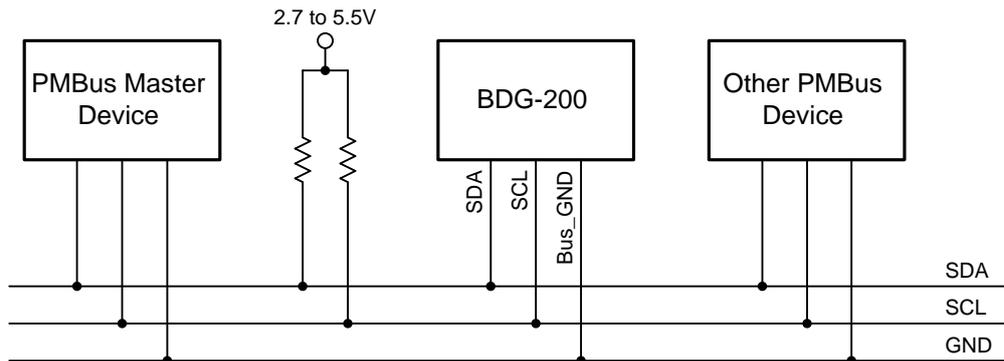
Symbols and terms	Definition
Byte	8 bits
Word	16 bits (2 bytes)
Set	Set bit to logic '1'
Clear	Set bit to logic '0'
nnb	Number 'nn' as a binary number.
nnh	Number 'nn' as a hexadecimal number.

## 9-2 Communication method

The serial interface of this converter complies with PMBus Specification Revision 1.1. For detailed information about command transfer, etc., refer to PMBus specification (PMBus Power System Management Protocol Specification Part I, General Requirements, Transport And Electrical Interface – Revision 1.1 and PMBus Power System Management Protocol Specification Part II, Command Language – Revision 1.1).

## 9-3 Communication pins

Connect PMBus communication pins (SDA, SCL) to a 2.7V to 5.5V power supply through a pull-up resistor or by a similar circuit. When serial communication is not used, leave PMBus communication pins open.



GND pin of PMBus interface (Bus\_GND) is internally connected to the GND pin of standby output (SB\_GND). Therefore, if ground may be unstable, for example, due to pulse load connected to the standby output, the stability of communication may be affected.

### 9-3-1 SDA pin

The SDA pin is used for data input and output in the serial communication. When used as output, the pin is configured as an open drain output.

- Input Low level: 0 to 0.8V
- Input High Level: 2.1V min.
- Output Low level: 0.4V max. (sink current 5mA max.)

### 9-3-2 SCL pin

The SCL pin is used for clock input in the serial communication.

The SCL pin is not driven by the converter. The SCL pin is driven by the bus master device.

- Input Low level: 0 to 0.8V
- Input High level: 2.1V min.

## 9-4 Device address setting

Since in the PMBus interface multiple devices share the same bus, each device can be identified by its own device address. The device address should be unique on the same bus.

The device address can be set by connecting or leaving opened between ADDR0, ADDR1, ADDR2 and SB\_GND pins. The correspondence between state of ADDR0, ADDR1 and ADDR2 pins and device addresses are shown in the list below. Device address is set according to the status of ADDR0, ADDR1 and ADDR2 pins at power on. Even though the status of ADDR0, ADDR1 and ADDR2 pins change after power on, the device address will not change.

Device address	ADDR2 – SB_GND	ADDR1 – SB_GND	ADDR0 – SB_GND
1011 000	Short circuit	Short circuit	Short circuit
1011 001	Short circuit	Short circuit	Open
1011 010	Short circuit	Open	Short circuit
1011 011	Short circuit	Open	Open
1011 100	Open	Short circuit	Short circuit
1011 101	Open	Short circuit	Open
1011 110	Open	Open	Short circuit
1011 111	Open	Open	Open

## 9-5 Data format

## 9-5-1 DIRECT Data Format

The data format consists from the following elements.

- $X$ : Actual value
- $Y$ : A value read or written in Data Byte of a PMBus command (2-byte signed integer represented as 2's complement)
- $m$ : Slope coefficient
- $b$ : Offset value
- $R$ : Exponent

\* For  $m$ ,  $b$ ,  $R$  values refer to descriptions of correspondent PMBus commands.

The relationship between elements is shown by the following formula.

$$X = \frac{1}{m} (Y \times 10^{-R} - b)$$

$$Y = (m X + b) \times 10^R$$

## 9-6 PMBus command

## 9-6-1 The list of PMBus commands

The converter supports the PMBus commands shown in the following table.

PMBus command	Command code	Transaction type	Data size (Byte)	Data format	Default setting
PAGE	00h	R/W Byte	1	—	00h
OPERATION	01h	R/W Byte	1	—	00h
ON_OFF_CONFIG	02h	R/W Byte	1	—	17h
CLEAR_FAULTS	03h	Send Byte	0	—	—
STORE_USER_ALL	15h	Send Byte	0	—	—
RESTORE_USER_ALL	16h	Send Byte	0	—	—
VOUT_COMMAND	21h	R/W Word	2	DIRECT	5V: 1388h (5V) 12V: 2EE0h (12V) 24V: 5DC0h (24V)
VOUT_TRIM	22h	R/W Word	2	DIRECT	0000h (0V)
FREQUENCY_SWITCH ※	33h	R/W Word	2	DIRECT	0104h (260kHz)
VOUT_OV_FAULT_LIMIT	40h	R/W Word	2	DIRECT	5V: 1A5Eh (6.75V) 12V: 3F48h (16.2V) 24V: 7E90h (32.4V)
IOUT_OC_FAULT_LIMIT	46h	R/W Word	2	DIRECT	5V: 3EE4h (16.1A) 12V: 1AF4h (6.9A) 24V: 0E74h (3.7A)
TON_DELAY	60h	R/W Word	2	DIRECT	0000h (0ms)
TON_RISE	61h	R/W Word	2	DIRECT	0064h (100ms)
TOFF_DELAY	64h	R/W Word	2	DIRECT	0000h (0ms)
STATUS_BYTE	78h	Read Byte	1	—	—
STATUS_WORD	79h	Read Word	2	—	—
STATUS_VOUT	7Ah	Read Byte	1	—	—
STATUS_IOUT	7Bh	Read Byte	1	—	—
STATUS_INPUT	7Ch	Read Byte	1	—	—
STATUS_TEMPERATURE	7Dh	Read Byte	1	—	—
STATUS_CML	7Eh	Read Byte	1	—	—
STATUS_MFR_SPECIFIC	80h	Read Byte	1	—	—
READ_VIN	88h	Read Word	2	DIRECT	—
READ_VOUT	8Bh	Read Word	2	DIRECT	—
READ_IOUT	8Ch	Read Word	2	DIRECT	—
READ_TEMPERATURE_1	8Dh	Read Word	2	DIRECT	—
READ_TEMPERATURE_2	8Eh	Read Word	2	DIRECT	—
READ_OPERATING_TIME	D0h	Read Word	2	DIRECT	—
READ_ESTIMATED_LIFE	D1h	Read Word	2	DIRECT	—
STATUS_BYTE_HISTORY	D8h	Read Byte	1	—	—
STATUS_WORD_HISTORY	D9h	Read Word	2	—	—
STATUS_VOUT_HISTORY	DAh	Read Byte	1	—	—
STATUS_IOUT_HISTORY	DBh	Read Byte	1	—	—
STATUS_INPUT_HISTORY	DCh	Read Byte	1	—	—

STATUS_TEMPERATURE_HISTORY	DDh	Read Byte	1	—	—
STATUS_CML_HISTORY	DEh	Read Byte	1	—	—
STATUS_MFR_SPECIFIC_HISTORY	E0h	Read Byte	1	—	—

\* Settings can be changed only when all output channels are OFF.

The meaning of the Transaction type column from the previous table is shown below.

Transaction type	Communication Bus protocols
Send Byte	Send Byte Protocol
Read Byte	Read Byte Protocol
Read Word	Read Word Protocol
R/W Byte	Read Byte Protocol and Write Byte Protocol
R/W Word	Read Word Protocol and Write Word Protocol

#### 9-6-2 PAGE command (00h)

This command is used to select the output channel for control.

Data size: 1 byte.

Data byte	Control channel
00h	Ch1 output
01h	Ch2 output
02h	Ch3 output
03h	Primary side (STATUS_TEMPERATURE only. Not used in other commands.)
04h to FEh	Not used
FFh	All channels (OPERATION only. Not used in other commands.)

The setting made by the PAGE command affects the following commands. Commands other than below are not affected by the setting made by the PAGE command.

- OPERATION
- VOUT\_COMMAND
- VOUT\_TRIM
- VOUT\_OV\_FAULT\_LIMIT
- IOUT\_OC\_FAULT\_LIMIT
- TON\_DELAY
- TON\_RISE
- TOFF\_DELAY
- STATUS\_VOUT
- STATUS\_IOUT
- STATUS\_TEMPERATURE
- READ\_VOUT
- READ\_IOUT
- READ\_TEMPERATURE\_2
- STATUS\_VOUT\_HISTORY
- STATUS\_IOUT\_HISTORY
- STATUS\_TEMPERATURE\_HISTORY

## 9-6-3 OPERATION command (01h)

This command is used for ON/OFF control.

Data size: 1 byte. Function of each bit is shown in the following table.

Bit				Output ON/OFF		Default setting
7 – 6	5 – 4	3 – 2	1 – 0			
00	XX	XX	XX	OFF	Turn-off sequence disabled Stop output without using the sequence specified by TOFF_DELAY command	●
01	XX	XX	XX	OFF	Turn-off sequence enabled Stop output using the sequence specified by TOFF_DELAY command	
10	00	XX	XX	ON	—	

Bits marked by X can have either 0 or 1 value; they do not affect the operation.

If a combination of values not shown above is set, the behavior is undefined.

The read/write target is set by the PAGE command. PAGE 00h to 02h sets the output channel 1 to 3, PAGE FFh sets all output channels. For example, when turning ON the output channel 1, the output will not turn ON unless PAGE 00h is set to ON and PAGE FFh is set to ON (the order of setting is irrelevant).

When ON / OFF control by serial communication is disabled using the ON\_OFF\_CONFIG command (bit 4 or bit 3 cleared), ON / OFF control cannot be performed using this command.

## 9-6-4 ON\_OFF\_CONFIG command (02h)

This command is used to set the ON/OFF control operation.

Data size: 1 byte. Function of each bit is shown in the following table.

Bit	Purpose	Value	Description	Default setting
7-5	Reserved	Ignored	Not used	
4	ON/OFF control enable / disable	0	Disable ON / OFF control by ON / OFF pin and serial communication	
		1	Enable ON / OFF control by ON / OFF pin and serial communication *	●
3	Enable / disable ON/OFF control by serial communication	0	Disable ON/OFF control by serial communication	●
		1	Enable ON/OFF control by serial communication	
2	Enable / disable ON/OFF control by ON/OFF pin	0	Disable ON/OFF control by ON/OFF pin	
		1	Enable ON/OFF control by ON/OFF pin	●
1	Select control logic for ON/OFF pin	0	Negative logic (ON when short circuit)	
		1	Positive logic (ON when open)	●
0	Enable / disable turn-off sequence when turned OFF by ON/OFF pin	0	Stop output using the sequence specified by TOFF_DELAY command	
		1	Stop output without using the sequence specified by TOFF_DELAY command	●

\*Follow the setting of bits 3-0.

When ON / OFF control by the ON / OFF pin and by serial communication are both enabled (bits 4-2 are all set), the output will not turn ON until both controls are set to ON.

## 9-6-5 CLEAR\_FAULTS command (03h)

This command is used to clear the status register.

Bits of the status register linked to the protection function that latches the stop state are not cleared by the CLEAR\_FAULTS instruction.

This command only clears the status register, and it does not release the latch stop state set by the protection.

## 9-6-6 STORE\_USER\_ALL command (15h)

This command stores the contents of operating memory in nonvolatile user store memory.

Note: Always maintain the input voltage for 1 second after execution of this command. Otherwise the contents of the user store memory may be destroyed, making its recovery impossible.

## 9-6-7 RESTORE\_USER\_ALL command (16h)

This command overwrites the contents of operating memory with the data stored in the nonvolatile user store memory.

9-6-8 VOUT\_COMMAND command (21h)

This command is used to set the output voltage.

Data size: 2 bytes, DIRECT Format is used (units: V). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 3$ .

The target output channel for read/write operation is set by the PAGE command.

9-6-9 VOUT\_TRIM command (22h)

This command is used to set output voltage trimming.

Data size: 2 bytes, DIRECT Format is used (units: V). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 3$ .

The target output channel for read/write operation is set by the PAGE command.

9-6-10 FREQUENCY\_SWITCH command (33h)

This command is used to set the switching frequency.

Data size: 2 bytes, DIRECT Format is used (units: kHz). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

9-6-11 VOUT\_OV\_FAULT\_LIMIT command (40h)

This command is used to set the output overvoltage protection threshold.

Data size: 2 bytes, DIRECT Format is used (units: V). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 3$ .

The target output channel for read/write operation is set by the PAGE command.

9-6-12 IOUT\_OC\_FAULT\_LIMIT command (46h)

This command is used to set the output overcurrent protection threshold.

Data size: 2 bytes, DIRECT Format is used (units: A). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 3$ .

The target output channel for read/write operation is set by the PAGE command.

9-6-13 TON\_DELAY command (60h)

This command is used to set the Turn-on Delay parameter.

Data size: 2 bytes, DIRECT Format is used (units: ms). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

The target output channel for read/write operation is set by the PAGE command.

9-6-14 TON\_RISE command (61h)

This command is used to set the Turn-on Rise parameter.

Data size: 2 bytes, DIRECT Format is used (units: ms). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

The target output channel for read/write operation is set by the PAGE command.

9-6-15 TOFF\_DELAY command (64h)

This command is used to set the Turn-off Delay parameter.

Data size: 2 bytes, DIRECT Format is used (units: ms). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

The target output channel for read/write operation is set by the PAGE command.

## 9-6-16 STATUS\_BYTE command (78h)

This command is used to read the STATUS\_BYTE register.

The STATUS\_BYTE is a 1 byte register. Function of each bit is shown in the following table.

Bit	Bit name	Description
7	BUSY	0 at all times
6	OFF	0 at all times
5	VOUT_OV	Set when overvoltage protection activates for one or more channels
4	IOUT_OC	Set when overcurrent protection activates for one or more channels
3	VIN_UV	Set when undervoltage lock out function activates
2	TEMPERATURE	Set when overheat protection activates
1	CML	Set when one or more bits of the STATUS_CML register are set
0	NONE OF ABOVE	Set when input overvoltage protection activates, or when one or more bits of the STATUS_MFR_SPECIFIC register are set.

## 9-6-17 STATUS\_WORD command (79h)

This command is used to read the STATUS\_WORD register.

The STATUS\_WORD is a 2 byte register. Function of each bit is shown in the following table.

	Bit	Bit name	Description
Lower part	7	BUSY	0 at all times
	6	OFF	0 at all times
	5	VOUT_OV	Set when overvoltage protection activates for one or more channels
	4	IOUT_OC	Set when overcurrent protection activates for one or more channels
	3	VIN_UV	Set when undervoltage lock out function activates
	2	TEMPERATURE	Set when overheat protection activates
	1	CML	Set when one or more bits of the STATUS_CML register are set
	0	NONE OF ABOVE	Set when input overvoltage protection activates, or when one or more bits of the STATUS_MFR_SPECIFIC register are set.
Upper part	7	VOUT	Set when one or more bits of the STATUS_VOUT register for one or more channels are set
	6	IOUT	Set when one or more bits of the STATUS_IOUT register for one or more channels are set
	5	INPUT	Set when one or more bits of the STATUS_INPUT register are set
	4	MFR	Set when one or more bits of the STATUS_MFR_SPECIFIC register are set
	3	POWER_GOOD#	0 at all times
	2	FANS	0 at all times
	1	OTHER	0 at all times
	0	UNKNOWN	0 at all times

## 9-6-18 STATUS\_VOUT command (7Ah)

This command is used to read the STATUS\_VOUT register.

The STATUS\_VOUT is a 1 byte register. Function of each bit is shown in the following table.

Bit	Description
7	Set when output overvoltage protection triggers
6	0 at all times
5	0 at all times
4	0 at all times
3	0 at all times
2	0 at all times
1	0 at all times
0	0 at all times

The target output channel for read operation is set by the PAGE command.

## 9-6-19 STATUS\_IOUT command (7Bh)

This command is used to read the STATUS\_IOUT register.

The STATUS\_IOUT is a 1 byte register. Function of each bit is shown in the following table.

Bit	Description
7	Set when output overcurrent protection activates
6	0 at all times
5	0 at all times
4	0 at all times
3	0 at all times
2	0 at all times
1	0 at all times
0	0 at all times

The target output channel for read operation is set by the PAGE command.

## 9-6-20 STATUS\_INPUT command (7Ch)

This command is used to read the STATUS\_INPUT register.

The STATUS\_INPUT is a 1 byte register. Function of each bit is shown in the following table.

Bit	Description
7	Set when input overvoltage detection activates
6	0 at all times
5	0 at all times
4	Set when undervoltage lock out function activates
3	0 at all times
2	0 at all times
1	0 at all times
0	0 at all times

## 9-6-21 STATUS\_TEMPERATURE command (7Dh)

This command is used to read the STATUS\_TEMPERATURE register.

The STATUS\_TEMPERATURE is a 1 byte register. Function of each bit is shown in the following table.

Bit	Description
7	Set when overheat protection activates
6	0 at all times
5	0 at all times
4	0 at all times
3	0 at all times
2	0 at all times
1	0 at all times
0	0 at all times

The target of read operation is set by the PAGE command. PAGE 00h to 02h sets the output channel 1 to 3, PAGE 03h sets primary side.

## 9-6-22 STATUS\_CML command (7Eh)

This command is used to read the STATUS\_CML register.

The STATUS\_CML is a 1 byte register. Function of each bit is shown in the following table.

Bit	Description
7	Set when a command code not found in the list of PMBus command codes is used
6	Set when invalid data are received
5	Set when Packet Error Check fails
4	Set when memory read/write fails
3	0 at all times
2	0 at all times
1	0 at all times
0	0 at all times

## 9-6-23 STATUS\_MFR\_SPECIFIC command (80h)

This command is used to read the STATUS\_MFR\_SPECIFIC register.

The STATUS\_MFR\_SPECIFIC is a 1 byte register. Function of each bit is shown in the following table.

Bit	Description
7	0 at all times
6	Set when internal error 6 occurs
5	Set when internal error 5 occurs
4	Set when internal error 4 occurs
3	Set when internal error 3 occurs
2	Set when internal error 2 occurs
1	Set when internal error 1 occurs
0	Set when internal error 0 occurs

The meaning of internal errors is not disclosed.

If an internal error occurs repeatedly even after input voltage is reapplied, this may mean that the module is damaged. When internal error occurs, please contact manufacturer.

### 9-6-24 READ\_VIN command (88h)

This command is used to read the effective value of input voltage

Data size: 2 bytes, DIRECT Format is used (units: V). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 1$ .

### 9-6-25 READ\_VOUT command (8Bh)

This command is used to read the output voltage.

Data size: 2 bytes, DIRECT Format is used (units: V). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 3$ .

The target output channel for read operation is set by the PAGE command.

### 9-6-26 READ\_IOUT command (8Ch)

This command is used to read the output current.

Data size: 2 bytes, DIRECT Format is used (units: A). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 3$ .

The target output channel for read operation is set by the PAGE command.

### 9-6-27 READ\_TEMPERATURE\_1 command (8Dh)

This command is used to read temperature in the device (primary side).

Data size: 2 bytes, DIRECT Format is used (units: °C). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

### 9-6-28 READ\_TEMPERATURE\_2 command (8Eh)

This command is used to read temperature in the device (secondary side).

Data size: 2 bytes, DIRECT Format is used (units: °C). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

The target output channel for read operation is set by the PAGE command.

### 9-6-29 READ\_OPERATING\_TIME command (D0h)

This command is used to read the total operating time.

Data size: 2 bytes, DIRECT Format is used (units: days). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

### 9-6-30 READ\_ESTIMATED\_LIFE command (D1h)

This command is used to read the estimated life.

Data size: 2 bytes, DIRECT Format is used (units: days). Coefficients:  $m = 1$ ,  $b = 0$ ,  $R = 0$ .

### 9-6-31 STATUS\_BYTE\_HISTORY command (D8h)

This command is used to read the history of the STATUS\_BYTE register.

Data size: 1 byte.

### 9-6-32 STATUS\_WORD\_HISTORY command (D9h)

This command is used to read the history of the STATUS\_WORD register.

Data size: 2 bytes.

### 9-6-33 STATUS\_VOUT\_HISTORY command (DAh)

This command is used to read the history of the STATUS\_VOUT register.

Data size: 1 byte.

### 9-6-34 STATUS\_IOUT\_HISTORY command (DBh)

This command is used to read the history of the STATUS\_IOUT register.

Data size: 1 byte.

## 9-6-35 STATUS\_INPUT\_HISTORY command (DCh)

This command is used to read the history of the STATUS\_INPUT register.

Data size: 1 byte.

## 9-6-36 STATUS\_TEMPERATURE\_HISTORY command (DDh)

This command is used to read the history of the STATUS\_TEMPERATURE register.

Data size: 1 byte.

## 9-6-37 STATUS\_CML\_HISTORY command (DEh)

This command is used to read the history of the STATUS\_CML register.

Data size: 1 byte.

## 9-6-38 STATUS\_MFR\_SPECIFIC\_HISTORY command (E0h)

This command is used to read the history of the STATUS\_MFR\_SPECIFIC register.

Data size: 1 byte.

## 10. Vibration and shock testing

Vibration: 5 to 10Hz total amplitude 10mm, 10 to 55Hz acceleration 2G (1 hour in each of 3 directions)

Shock: acceleration 20G (3 times in each of 3 directions)  
shock time 11±5ms

## 11. Life expectancy

The expected life of the converter is given in the following table.

Mounting direction*	Ambient temperature	Life expectancy (switching frequency 260kHz, output power 100%)
A	40°C or less	6.3 years
B	40°C or less	4.2 years

\* See chapter 5. Temperature derating

## 12. Precautions for use

To ensure user's safety, check specifications before using the product and always observe the following precautions when using it.

- The product is intended for use in general electronics equipment (office equipment, communication equipment, measurement equipment). Do not use the product in medical equipment, nuclear equipment, trains, and other areas, where human life or property may be directly affected by damaged product, or in the environment with constant vibration. For any use other than in general electronics equipment please consult the manufacturer.
- While the product has a built-in overcurrent and short-circuit protection, a prolonged short circuit condition should be avoided as it can damage the product.
- The product may be damaged if used under nonstandard electrical or environmental conditions including temperature, etc. The product must be always used within specifications.
- Avoid storing or using the product in places where corrosive gas or dust are generated.
- The product may be damaged by static electricity. Take measures against static electricity in the working environment, such as using grounding straps to discharge the static charge on workers, etc.
- Do not replace fuses.
- The product contains parts under high voltage. Do not touch the product when input voltage is applied or right after input voltage is disconnected.
- The product contains hot parts. Do not touch the product when input voltage is applied or right after input voltage is disconnected.
- The product does not come with a test report.

## 13. Warranty

The warranty period of this product is one year. Should the product become defective within the warranty period due to defects in design or manufacture, it will be repaired or replaced free of charge. However, this warranty does not cover products which have been subjected to internal modifications, etc.

The scope of the warranty is limited to this product only.

## 14. Model names and configurations

The following table shows the correspondence between model names and unit configurations. If a configuration is absent in the table, please contact the manufacturer.

Model	Rated output		
	Channel 1	Channel 2	Channel 3
BDG-200-001	No unit	No unit	5V
BDG-200-002	No unit	No unit	12V
BDG-200-003	No unit	No unit	24V
BDG-200-011	No unit	5V	5V
BDG-200-012	No unit	5V	12V
BDG-200-013	No unit	5V	24V
BDG-200-022	No unit	12V	12V
BDG-200-023	No unit	12V	24V
BDG-200-033	No unit	24V	24V
BDG-200-111	5V	5V	5V
BDG-200-112	5V	5V	12V
BDG-200-113	5V	5V	24V
BDG-200-122	5V	12V	12V
BDG-200-123	5V	12V	24V
BDG-200-133	5V	24V	24V
BDG-200-222	12V	12V	12V
BDG-200-223	12V	12V	24V
BDG-200-233	12V	24V	24V
BDG-200-333	24V	24V	24V