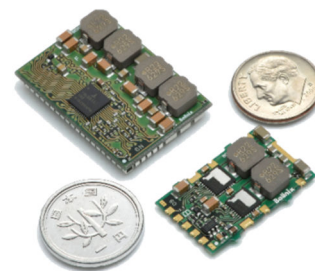


This product is a step down DC-DC converter that has a feature to change settings such as output voltage, turn-on sequence and turn-off sequence via serial communication (PMBus/AVSBus) during operation. Furthermore, the product is equipped with digital control feature achieving high output voltage accuracy and ultra high-speed response.



■ Features

- Output Voltage Accuracy $\pm 0.5\%$
- Ultra High-Speed Response
- Small foot print, high power density
- High-speed serial communication via AVSBus
- Overcurrent protection
- Under Voltage Lock Out
- ON/OFF Control
- Adjustable Output Voltage (via PMBus/AVSBus)
- Output Overvoltage Protection
- Settings can be changed and monitored during operation via serial communication (PMBus,AVSBus)
- Turn-on and turn-off sequences can be configured (via PMBus)
- High reliability, High performance
- SMD package
- Non-Isolated Converter
- Operating temperature -40°C to $+85^{\circ}\text{C}$ (Temperature derating required)
- RoHS compliant

■ Rating

Table 1 ※1

Models BDP Series	Input V Vdc	Output V Vdc	Output I A	Line Reg. %(typ.)	Load Reg. %(typ.)	Noise mVpp(typ.)	Efficiency %(typ.)
BDX12-1.0S100RM ※4	12V (8.0 to 14.0)	1.0 (0.5 to 1.2)	0 to 100 ※3	0.2	0.2	20 ※2	89 (Io=50%)
BDX12-1.0S50R0S ※5	12V (8.0 to 14.0)	1.0 (0.5 to 1.2)	+50A ※3 ※6	0.2	0.2	20 ※2	89 ※7 (Io=50%)

- ※1 : Unless otherwise specified, the product is measured at input voltage 12V, output voltage 1.0V, output current 100%, ambient temperature $25^{\circ}\text{C}\pm 5^{\circ}\text{C}$.
- ※2 : BW=20MHz.
- ※3 : Depending on ambient temperature, temperature derating and forced air cooling may be required.
- ※4 : It is possible to operate by itself. When connecting in parallel, it becomes the master unit.
- ※5 : It is a slave unit for parallel operation or dual output operation along with BDX12-1.0S100RM. Does not operate as a single unit.
- ※6 : By connecting in parallel with BDX12-1.0S100RM, total output current can be added by 50A per BDX12-1.0S50R0S (total output current 350 A max.)
- ※7 : When 1 unit of BDX12-1.0S50R0S is used in parallel operation.

■ Specification

Table 2

	BDX12-1.0S100RM	BDX12-1.0S50R0S
Input voltage range	Refer to Table 1	
Rated input voltage	12V	12V
Rated output voltage	1.0V	1.0V
Default preset output voltage	1.0V	1.0V
Adjustable output voltage range	Refer to Table 1	
Output voltage accuracy	$\pm 0.5\%$	$\pm 0.5\%$
Line regulation	Refer to Table 1 (Rated output, Input voltage varying in the range of Table 1)	
Load regulation	Refer to Table 1 (Rated I/O voltage, output current varying from 0 to 100%)	
Ripple noise	Refer to Table 1 (Rated input/output, measurement frequency bandwidth 20MHz)	
Efficiency	Refer to Table 1 (Rated input, output current 50%)	Refer to Table 1 (Rated input, output current 50%, when 1unit used)
Overcurrent protection	Yes	
Under voltage lock out	Yes	
Output overvoltage protection	Yes	
Remote ON/OFF	Yes	
P-Good signal	Yes	
Remote sensing	Yes	
Operating temperature range	-40°C to $+85^{\circ}\text{C}$ (Refer to temperature derating described separately)	
Storage temperature range	-40°C to $+85^{\circ}\text{C}$	
Humidity	20 to 95%R.H. (Max. wet bulb temperature 69°C with no condensation)	
Storage condition	Below 30°C /60% R.H before mounting	
Cooling condition	Refer to temperature derating described separately	
Weight	9.46g typ.	2.85g typ.
Outer dimensions	W=32.8 L=23.0 H=7.0(mm) (Refer to outer dimensions described separately)	W=16.5 L=27.0 H=3.95(mm) (Refer to outer dimensions described separately)

* The above specifications are provided with rated value, unless otherwise specified.
 * The contents provided in this datasheet may be changed at any time without prior notice.

1. Scope

These specifications shall apply to the non-isolated type DC-DC converter, BDX12-1.0S100RM and BDX12-1.0S50R0S.

2. Model/Rating

Model Name	Rated input voltage	Rated output	Shape	Remarks
BDX12-1.0S100RM *1	DC 12.0V	DC 1.0V, 100A	SMD	
BDX12-1.0S50R0S *2	DC 12.0V	DC 1.0V, +50A *3	SMD	Total output current 350A max. *4

Unless otherwise mentioned in the specifications, input shall be rated input, output shall be rated output and ambient temperature shall be 25°C±5°C.

*1 Operates as a single unit. When connecting in parallel, it becomes the master unit.

*2 It is a slave unit for parallel operation or dual output operation along with BDX12-1.0S100RM. Does not operate as a single unit.

*3 By connecting in parallel with BDX12-1.0S100RM, total output current can be added by 50A per BDX12-1.0S50R0S.

*4 When using parallel and dual output operation together, the maximum configuration will be VOUT1: 300A max., VOUT2: 50A max. For details, refer to section 7-3 and "BDX series Parallel, Dual output operation Application Note".

3. Environmental conditions

3-1 Temperature range

In operation -40°C to +85°C (Derating required)

In storage -40°C to +85°C

3-2 Humidity range

In operation 20 to 95%R.H. (However, max. wet bulb temperature 69°C, no condensation)

In storage 20 to 95%R.H. (However, max. wet bulb temperature 69°C, no condensation)

Note) Store in a place below 30°C/60% R.H. before mounting.

4. Specifications & Standards

The product is RoHS compliant.

4-1 Input characteristics

Item	Specifications & Standards	Conditions
Input voltage	8.0 to 14.0V (Rating 12.0V)	

4-2 BDX12-1.0S100RM (VOUT1) Output characteristics and functions

Characteristics when BDX12-1.0S100RM is operated as a single unit (VOUT1).

*1, *2

Item	Specifications & Standards	Conditions
Rated output voltage	1.0V	
Output voltage by default	1.0V	
Output voltage tolerance	1.0V±0.5% max.	Output current at 0%
Adjustable output voltage range	500 to 1200mV	Configured via serial communication
Output current	0 to 100A	Derating required
Line regulation	0.2% typ. 0.5% max.	Input varying from 8.0 to 14V
Load regulation	0.2% typ. 0.5% max.	Output current varying from 0 to 100%
Temperature regulation	±0.003%/°C typ.	Temperature varying from -40 to +85°C
Integrated regulation	±1.0% max.	Including line regulation, load regulation, temp. regulation.*3
Ripple noise	20mVp-p typ. 50mVp-p max.	BW = 20MHz
Efficiency	89% typ.	Output current at 50%
	86% typ.	Output current at 100%
Overcurrent protection	Operates at 105% or above (auto restart type)	Refer to section 8-15 for operation.
Maximum output capacitance	20mF (= 20000μF)	*4
Under Voltage Lock Out	Yes Activation voltage: 7.5V typ. Deactivation voltage: 6.8V typ.	Refer to section 8-12 for operation.
ON/OFF control	Between ON/OFF1 pin - SGND pin ON when open OFF when short circuit or low	Refer to section 8-7-1 for voltage at open and low.
P-Good output	At normal output: High At abnormal output: Low	Refer to section 8-10 for voltage at high and low.
Output overvoltage protection	Shut down	Refer to section 8-14 for operation.
Serial communication feature	PMBus 1.3 compliance AVSBus compliance	
Sequence feature	Yes (via PMBus communication)	
Monitoring feature	Yes (via serial communication)	
Oscillation frequency setup	600kHz×2Phase	Fixed

*1 With measurement circuit of section 4-5 .

*2 Unless otherwise specified, the following measurement conditions will be applied.

Input voltage 12.0V, output voltage 1.0V, output current 100% and ambient temperature 25°C±5°C.

*3 Value is designed value.

*4 Maximum output capacitance depends on the output voltage and turn-on time when start-up, and on the characteristic of added capacitor. Make sure to check with the actual device. Contact us, if necessary to increase the output capacitance more than the maximum capacitance.

4-3 BDX12-1.0S100RM // BDX12-1.0S50R0S (VOUT1) Output characteristics

Characteristics when BDX12-1.0S100RM and BDX12-1.0S50R0S are in parallel operation (VOUT1).

*1, *2

Item	Specifications & Standards	Conditions
Rated output voltage	1.0V	
Output voltage by default	1.0V	
Output voltage tolerance	1.0V±0.5% max.	Output current at 0%
Adjustable output voltage range	500 to 1200mV	Configured via serial communication
Output current	BDX12-1.0S50R0S × 1 unit: 0 to 150A BDX12-1.0S50R0S × 2 units: 0 to 200A BDX12-1.0S50R0S × 3 units: 0 to 250A BDX12-1.0S50R0S × 4 units: 0 to 300A BDX12-1.0S50R0S × 5 units: 0 to 350A	Derating required
Line regulation	0.2% typ. 0.5% max.	Input varying from 8.0 to 14V
Load regulation	0.2% typ. 0.5% max.	Output current varying from 0 to 100%
Temperature regulation	±0.003%/°C typ.	Temperature varying from -40 to +85°C
Integrated regulation	BDX12-1.0S50R0S × 1 unit: ±1.0% max.	Including line regulation, load regulation, temp. regulation.*3
Ripple noise	20mVp-p typ. 50mVp-p max.	BW = 20MHz
Efficiency	BDX12-1.0S50R0S × 1 unit: 89% typ. BDX12-1.0S50R0S × 5 units: 88% typ.	Output current at 50%
	BDX12-1.0S50R0S × 1 unit: 86% typ. BDX12-1.0S50R0S × 5 units: 84% typ.	Output current at 100%
Overcurrent protection	Operates at 105% or above (auto restart type)	Refer to section 8-15 for operation.
Maximum output capacitance	20mF (= 20000μF)	*4
Oscillation frequency setup	BDX12-1.0S50R0S × 1 unit: 600kHz typ. × 3Phase BDX12-1.0S50R0S × 2 units: 600kHz typ. × 4Phase BDX12-1.0S50R0S × 3 units: 600kHz typ. × 5Phase BDX12-1.0S50R0S × 4 units: 600kHz typ. × 6Phase BDX12-1.0S50R0S × 5 units: 600kHz typ. × 7Phase	Fixed

*1 With measurement circuit of section 4-5.

*2 Unless otherwise specified, the following measurement conditions will be applied.

Input voltage 12.0V, output voltage 1.0V, output current 100% and ambient temperature 25°C±5°C.

*3 Value is designed value.

*4 Maximum output capacitance depends on the output voltage and turn-on time when start-up, and on the characteristic of added capacitor. Make sure to check with the actual device. Contact us, if necessary to increase the output capacitance more than the maximum capacitance.

4-4 BDX12-1.0S50R0S Dual output (VOUT2) characteristics

Characteristics when BDX12-1.0S50R0S are in dual output operation (VOUT2).

*1, *2

Item	Specifications & Standards	Conditions
Rated output voltage	1.0V	
Output voltage by default	1.0V	
Output voltage tolerance	1.0V±0.5% max.	Output current at 0%
Adjustable output voltage range	500 to 1200mV	Configured via serial communication
Output current	0 to 50A	Derating required
Line regulation	0.2% typ. 0.5% max.	Input varying from 8.0 to 14V
Load regulation	0.2% typ. 0.5% max.	Output current varying from 0 to 100%
Temperature regulation	±0.003%/°C typ.	Temperature varying from -40 to +85°C
Integrated regulation	±1.0% max.	Including line regulation, load regulation, temp. regulation. *3
Ripple noise	20mVp-p typ. 50mVp-p max.	BW = 20MHz
Efficiency	89% typ.	VOUT1, VOUT2 when both output current at 50%
	86% typ.	VOUT1, VOUT2 when both output current at 100%
Overcurrent protection	Operates at 105% or above (auto restart type)	Refer to section 8-15 for operation
Maximum output capacitance	10mF (= 10000μF)	*4
Oscillation frequency setup	500kHz	Fixed

*1 With measurement circuit of 4-5

*2 Unless otherwise specified, the following measurement conditions will be applied.

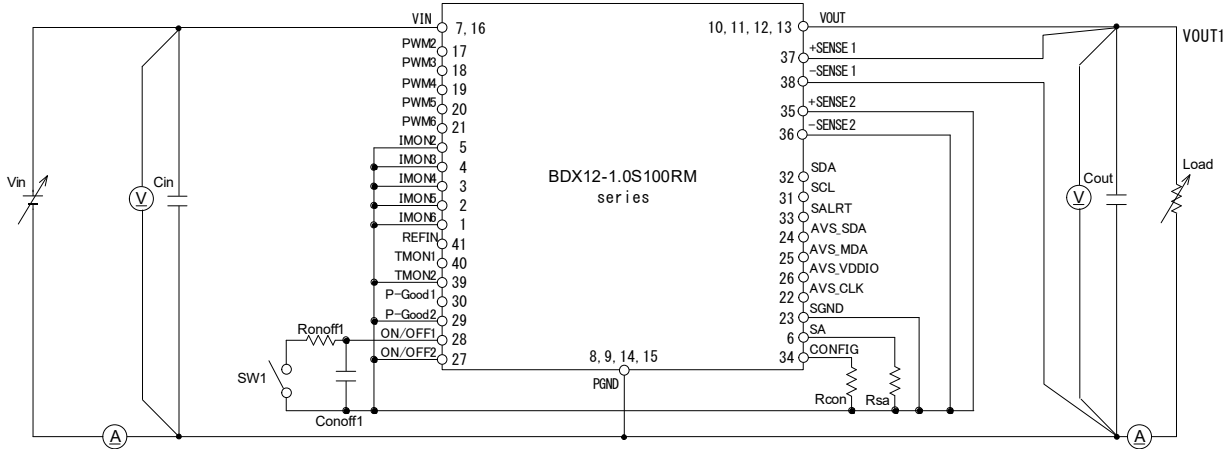
Input voltage 12.0V, output voltage 1.0V, output current 100% and ambient temperature 25°C±5°C.

*3 Value is designed value.

*4 Maximum output capacitance depends on the output voltage and turn-on time when start-up, and on the characteristic of added capacitor. Make sure to check with the actual device. Contact us, if necessary to increase the output capacitance more than the maximum capacitance.

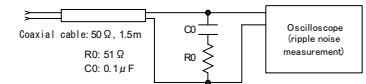
4-5 Measurement circuit

4-5-1 BDX12-1.0S100RM Single operation measurement circuit



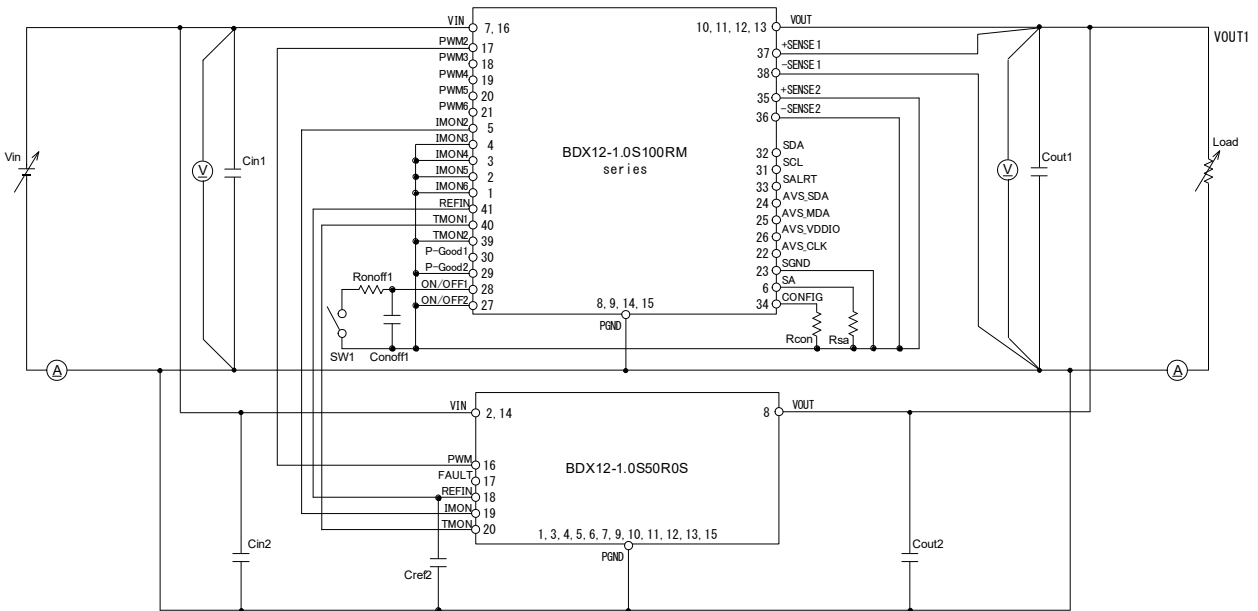
Cin: 22 μ F (3225 size Multi-layer ceramic capacitor) \times 4,
 10 μ F (3216 size Multi-layer ceramic capacitor) \times 4
 Cout: 100 μ F (3216 size Multi-layer ceramic capacitor) \times 8

Rsa: Address setting resistor
 Rcon: 5.6k Ω (Configuration ID setting resistor standard setting)
 Ronoff1: 10 Ω
 Conoff1: 0.1 μ F (1005 size Multi-layer ceramic capacitor)



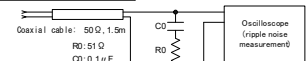
SW1 (VOUT1 ON/OFF control)
 Open = Output ON
 Short = Output OFF

4-5-2 BDX12-1.0S100RM // BDX12-1.0S50R0S Parallel operation measurement circuit



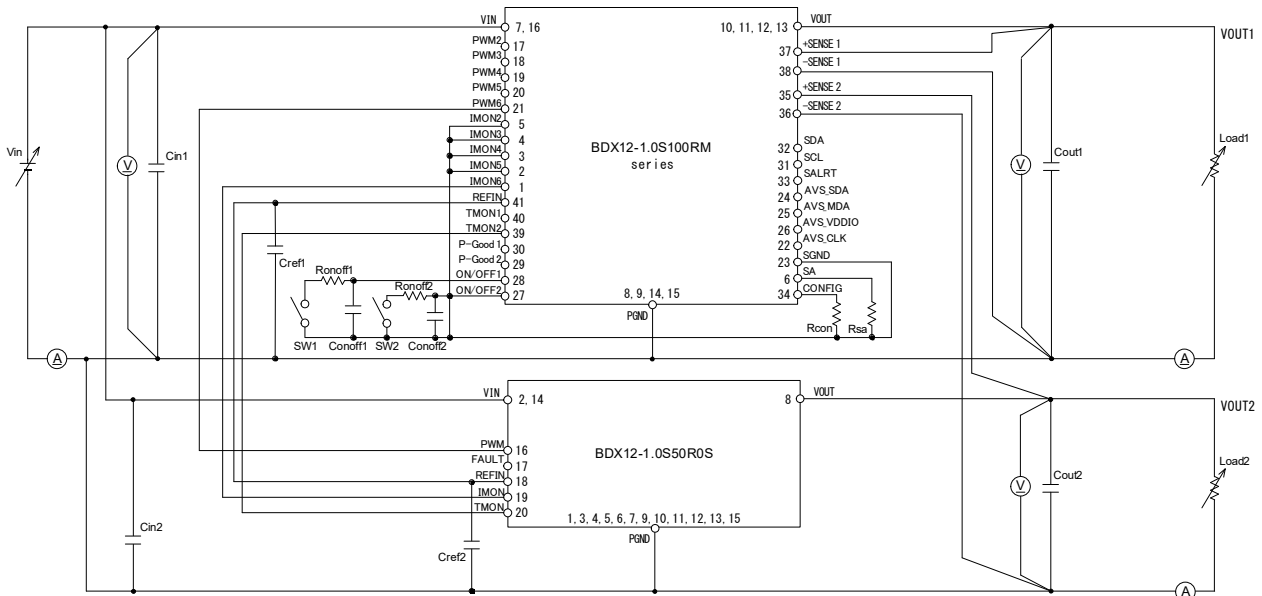
Cin1: 22 μ F (3225 size Multi-layer ceramic capacitor) \times 4,
 10 μ F (3216 size Multi-layer ceramic capacitor) \times 4
 Cin2: 10 μ F (3216 size Multi-layer ceramic capacitor) \times 4
 Cout1: 100 μ F (3216 size Multi-layer ceramic capacitor) \times 8,
 47 μ F (2012 size Multi-layer ceramic capacitor) \times 8
 Cout2: 100 μ F (3216 size Multi-layer ceramic capacitor) \times 4

Cref2: 0.1 μ F (1005 size Multi-layer ceramic capacitor)
 Rsa: Address setting resistor
 Rcon: Configuration ID setting resistor
 Ronoff1: 10 Ω
 Conoff1: 0.1 μ F (1005 size Multi-layer ceramic capacitor)



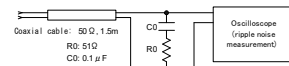
SW1 (VOUT1 ON/OFF control)
 Open: Output ON
 Short: Output OFF

4-5-3 BDX12-1.0S50R0S Dual output measurement circuit



- Cin1: 22uF (3225 size Multi-layer ceramic capacitor) × 4, 10uF (3216 size Multi-layer ceramic capacitor) × 4
- Cin2: 22uF (3225 size Multi-layer ceramic capacitor) × 4, 10uF (3216 size Multi-layer ceramic capacitor) × 8
- Cout1: 100uF (3216 size Multi-layer ceramic capacitor) × 8, 47uF (2012 size Multi-layer ceramic capacitor) × 8
- Cout2: 100uF (3216 size Multi-layer ceramic capacitor) × 4, 47uF (2012 size Multi-layer ceramic capacitor) × 16, 1000uF (7343 size Conductive polymer capacitor) × 1
- Cref1: 2.2uF (2012 size Multi-layer ceramic capacitor)
- Cref2: 0.1uF (1005 size Multi-layer ceramic capacitor)
- Rsa: Address setting resistor
- Rcon: Configuration ID setting resistor
- Rono1: 10Ω
- Rono2: 10Ω

- SW1 (VOUT1 ON/OFF control)
Open: Output ON
Short: Output OFF
- SW2 (VOUT2 ON/OFF control)
Open: Output ON
Short: Output OFF



5. Temperature derating

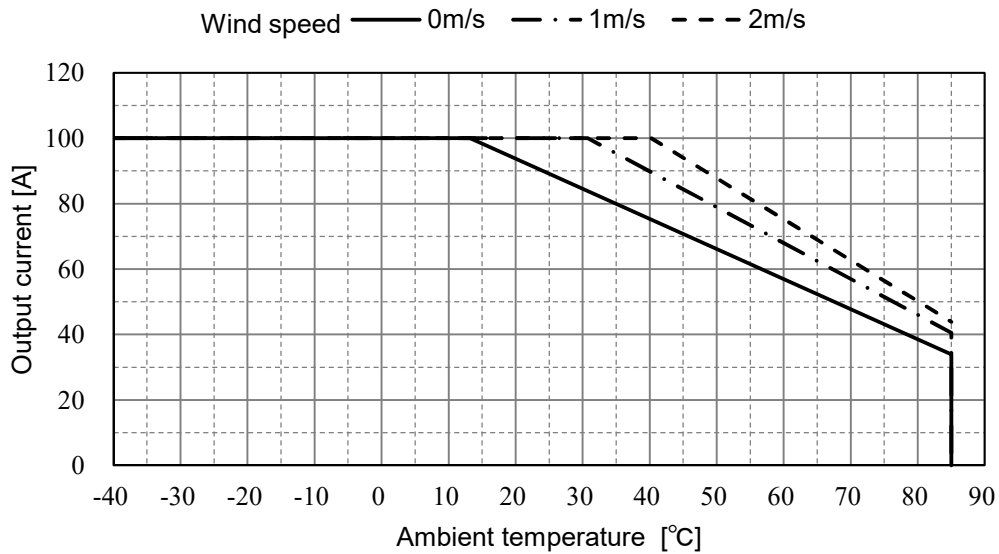
Install BDX series in a well-ventilated place.

Implement derating appropriate to usage environment.

Derating shall be according to ambient temperature and input voltage.

Temperature of the converter varies substantially depending on the board it is mounted on and on the ambient temperature. Ultimately, therefore, mount the converter onto a device which will actually be used with the converter. When operated with the actual equipment at the highest ambient temperature, temperature of the converter must not exceed the absolute maximum rating (112.5°C max.).

5-1 BDX12-1.0S100RM



<Energization condition>

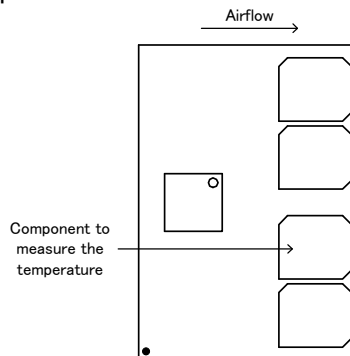
-Input voltage 12V

-Output voltage 1.0V

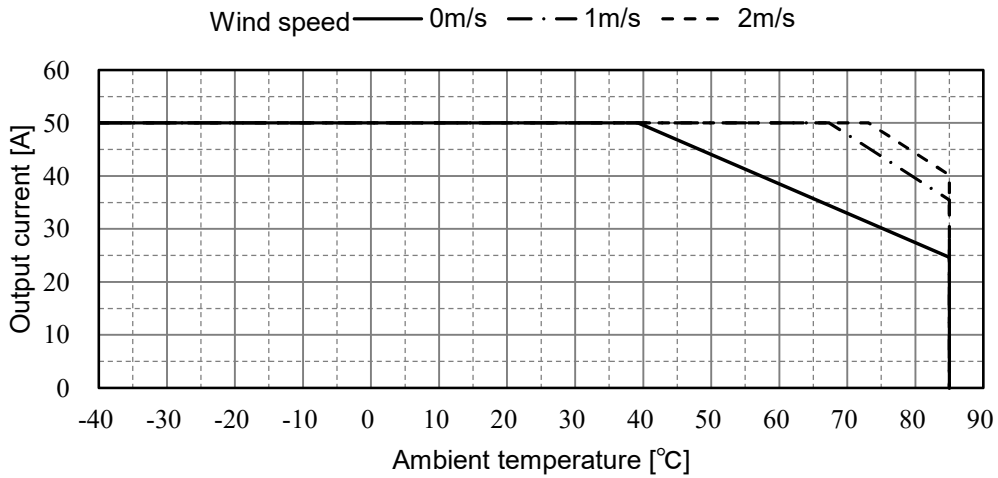
< Heat release pattern conditions >

Copper foil coating of 120 x 120 mm in dimension and 70μm thickness when mounted on a 6 layered board (Only BDX12-1.0S100RM is mounted)

<Air-flow direction, Condition of measuring temperature>



5-2 BDX12-1.0S50R0S (Parallel operation)



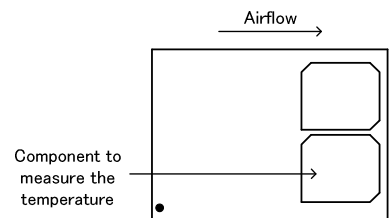
<Energization condition>

- Input voltage 12V
- Output voltage 1.0V

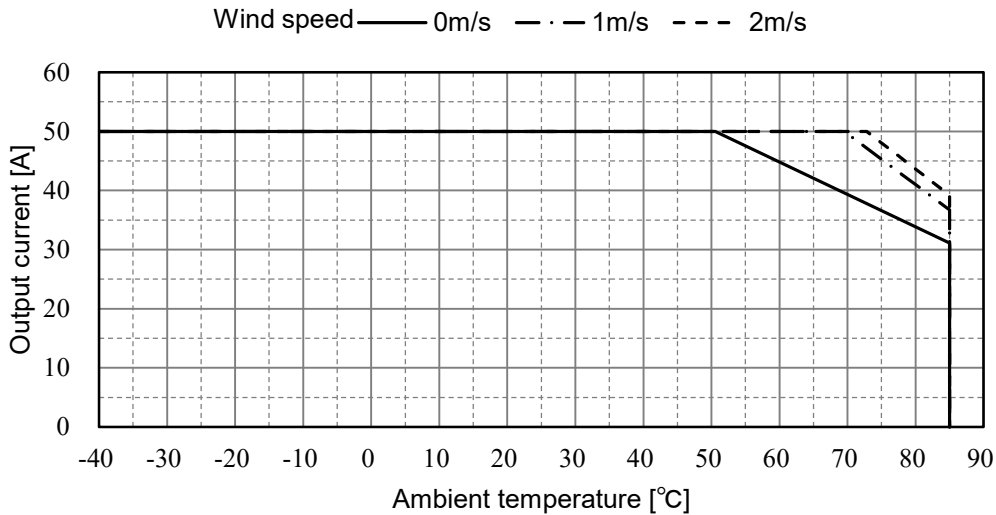
< Heat release pattern conditions >

Copper foil coating of 120 x 120 mm in dimension and 70μm thickness when mounted on a 6 layered board (Only BDX12-1.0S50R0S is mounted)

<Air-flow direction, Condition of measuring temperature>



5-3 BDX12-1.0S50R0S (Dual output operation)



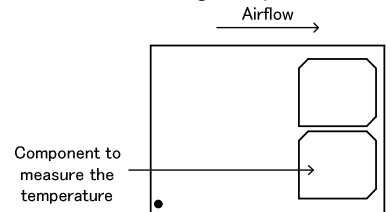
<Energization condition>

- Input voltage 12V
- Output voltage 1.0V

<Heat release pattern conditions>

Copper foil coating of 120×120mm in dimension and 70μm thickness when mounted on a 6 layered board (Only BDX12-1.0S50R0S is mounted)

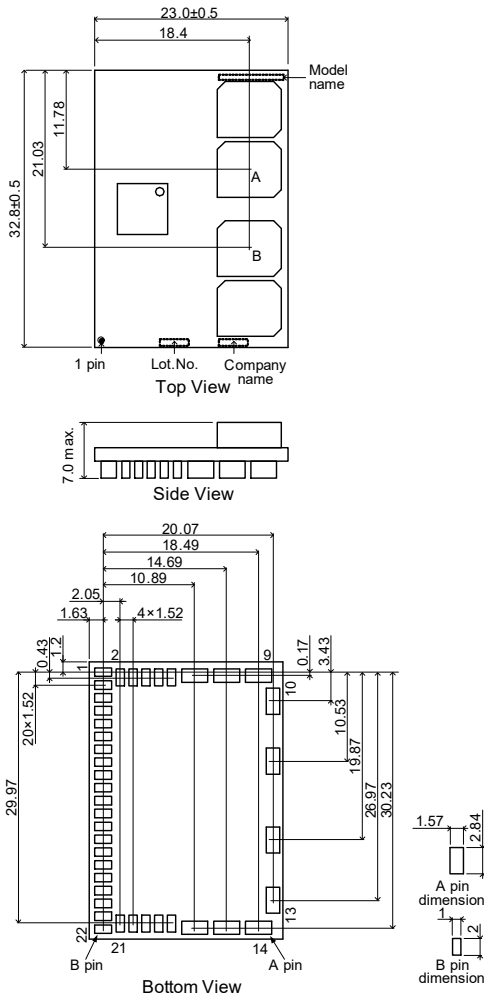
<Air-flow direction, Condition of measuring temperature>



<Air-flow direction, Condition of measuring temperature>

6. Outer dimensions and description of pins

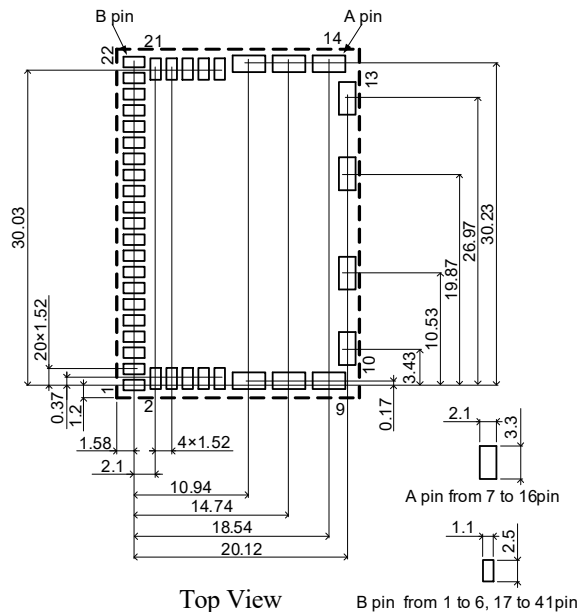
6-1 BDX12-1.0S100RM Shape and dimensions



When mounted by an automated machine, picking up at point A or B is needed.

Unit: mm
 Dimensional tolerance: ±0.2mm
 B pin space: 0.2mm min.

6-2 BDX12-1.0S100RM Recommended footprint



Unit: mm

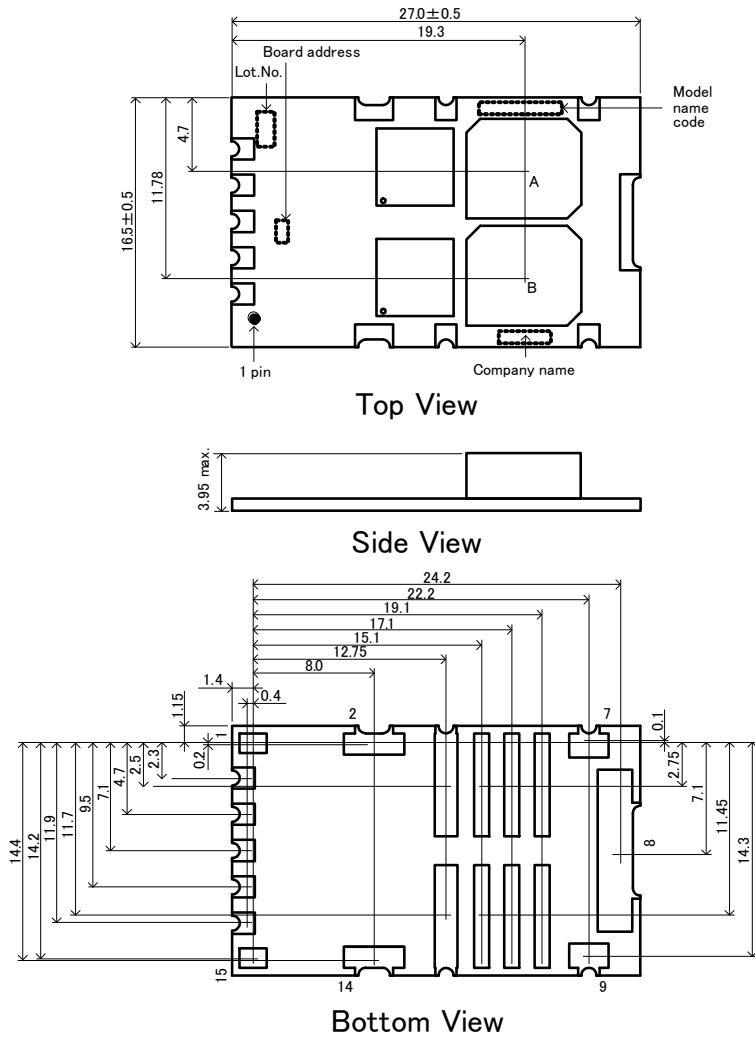
Note) Recommended layout is shown on the left. Use your design standard for your specific design.

6-3 BDX12-1.0S100RM Description of pins

Pin	Name	Function
7,16	VIN	Voltage input pin
8,9,14,15	PGND	Power ground pin
10,11,12,13	VOUT	Voltage output pin
1	IMON6	Current signal input pin *1
2	IMON5	Current signal input pin *1
3	IMON4	Current signal input pin *1
4	IMON3	Current signal input pin *1
5	IMON2	Current signal input pin *1
6	SA	Address setting pin
17	PWM2	PWM output pin
18	PWM3	PWM output pin
19	PWM4	PWM output pin
20	PWM5	PWM output pin
21	PWM6	PWM output pin
22	AVS_CLK	AVSBus clock input pin
23	SGND	Signal ground
24	AVS_SDA	AVSBus output pin
25	AVS_MDA	AVSBus input pin
26	AVS_VDDIO	AVSBus reference voltage input pin
27	ON/OFF2	VOUT2 Remote ON/OFF input pin
28	ON/OFF1	VOUT1 Remote ON/OFF input pin
29	P-Good2	VOUT2 Power-good output pin
30	P-Good1	VOUT1 Power-good output pin
31	SCL	PMBus clock input pin
32	SDA	PMBus data I/O pin
33	SALRT	PMBus alarm output pin
34	CONFIG	Configuration ID setting pin
35	+SENSE2	VOUT2 (+) Remote sensing pin *1
36	-SENSE2	VOUT2 (-) Remote sensing pin *1
37	+SENSE1	VOUT1 (+) Remote sensing pin *1
38	-SENSE1	VOUT1(-) Remote sensing pin *1
39	TMON2	VOUT2 Temperature signal input pin
40	TMON1	VOUT1 Temperature signal input pin
41	REFIN	Current signal reference voltage output pin *1

*1 Particular attention is required since these pins are related to the feedback loop. Make sure to refer to section 7 before use.

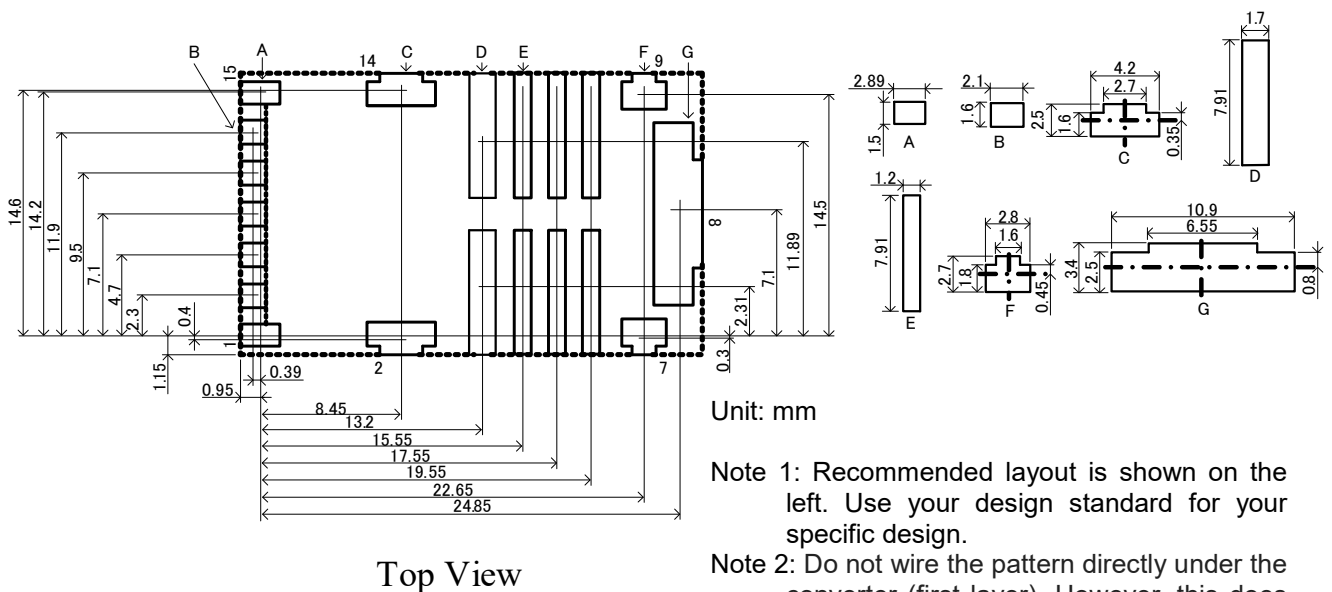
6-4 BDX12-1.0S50R0S Shape and dimensions



When mounted by an automated machine, picking up at point A or B is needed.

Unit: mm
Dimensional tolerance: ±0.2mm

6-5 BDX12-1.0S50R0S Recommended footprint



Unit: mm

Note 1: Recommended layout is shown on the left. Use your design standard for your specific design.

Note 2: Do not wire the pattern directly under the converter (first layer). However, this does not apply to recommended patterns shown in section 7-3

6-6 BDX12-1.0S50R0S Description of pins

Pin	Name	Function
2,14	VIN	Voltage input pin
3,7,9,13	PGND	Power ground pin
8	VOOUT	Voltage output pin
16	PWM	PWM input pin
17	FAULT	FAULT signal output pin
18	REFIN	Current signal reference voltage input pin *1
19	IMON	Current signal output pin *1
20	TMON	Temperature signal output pin
4,5,6,10,11,12	GND	Ground for heat dissipation
1,15	GND	Fixed pin (Connected to GND inside the converter.)

*1 Particular attention is required since these pins are related to the feedback loop. Make sure to refer to section 7 and the layout commentary in “BDX series Evaluation Board User Manual”.

6-7 Lot indication

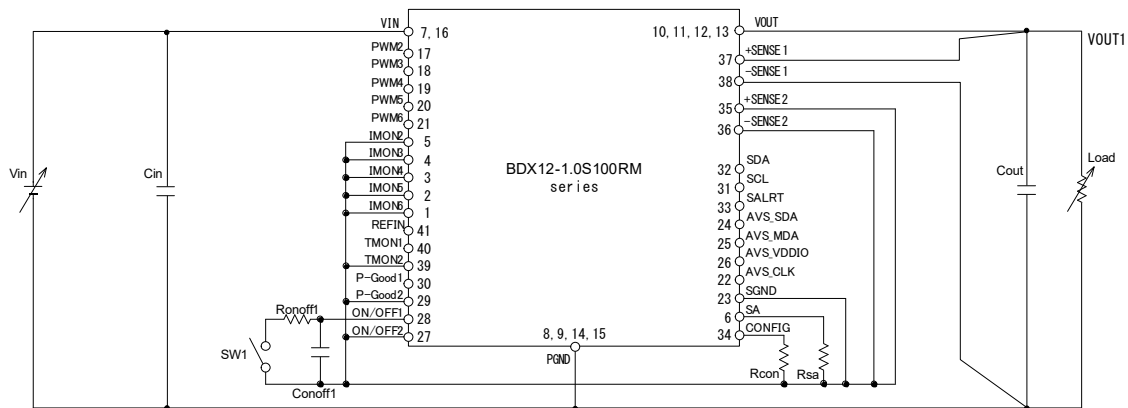
7 1 (Manufactured in January 2017)

7 D 2 (Manufactured in December 2017)

└─ Production code for manufacture control(may not be indicated)
└─ Manufacturing month (Jan to Sep=1 to 9, Oct=O, Nov=N, Dec=D)
└─ Manufacturing year (the last digit of A.D.)

7. Standard connection diagram/ Recommended layout

7-1 BDX12-1.0S100RM Single operation



Cin: 22 μ F (3225 size Multi-layer ceramic capacitor) \times 4,
10 μ F (3216 size Multi-layer ceramic capacitor) \times 4
Cout: 100 μ F (3216 size Multi-layer ceramic capacitor) \times 8

Rsa: Address setting resistor
Rcon: 5.6k Ω (Configuration ID setting resistor
standard setting)
Ronoff1: 10 Ω
Conoff1: 0.1 μ F (1005 size Multi-layer ceramic capacitor)

SW1 (VOUT1 ON/OFF control)
Open = Output ON
Short = Output OFF

Note 1: Make sure to connect the +SENSE1 and -SENSE1 pins to the converter.

Note 2: The SENSE line (the line from +SENSE1, -SENSE1 pin to the both sides of Cout) is related to the feedback loop. Since the SENSE line is sensitive to noise, do not route the wiring long as much as possible and wire it in parallel.

Note 3: When wiring between SW1 and the converter is extended and connected, overshoot and undershoot may occur on the ON/OFF 1 pin. In that case, please connect SW1 via RC filter (reference value: Ronoff 1 = 10 Ω , Conoff 1 = 0.1 μ F).

Note 4: Rsa is a resistor to set a device address via PMBus communication. Make sure to connect an appropriate resistor for the required address.

Note 5: Rcon is a resistor to set a configuration ID. Connect a resistor of a value according to the configuration ID to be called at startup. When using the standard setting, connect a 5.6 k Ω resistor.

Note 6: Leave the SALRT pin, SDA pin and SCL pin OPEN when the PMBus communication function is not used.

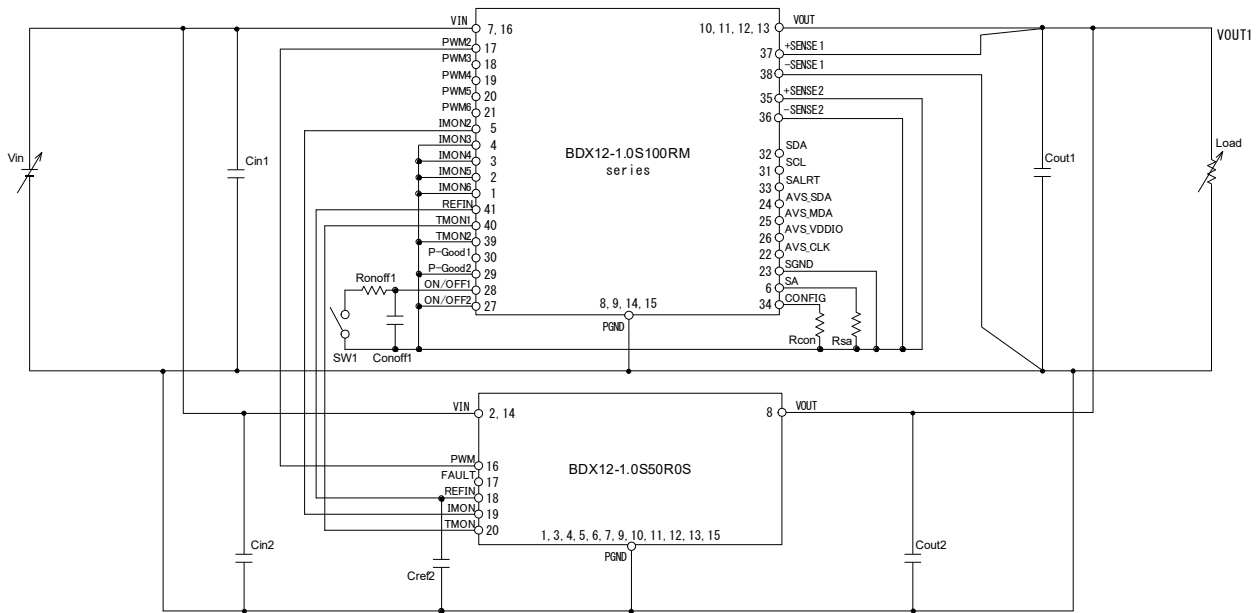
Note 7: When not using the AVSBus communication function, connect the AVS_CLK pin and AVS_MDA pin to the SGND pin, and leave the AVS_VDDIO pin and AVS_SDA pin OPEN.

Note 8: Make sure to add input/output capacitors (Cin, Cout) as close to the root of the converter as possible.

Note 9: Wire between the input power and the converter in order to lower line impedance. If the line impedance gets high, connect the capacitor which has appropriate capacity to operate stable input voltage to Cin in parallel.

Note 10: When adding the output capacitor Cout, the converter may not start depending on capacity. Make sure to check with the actual device.

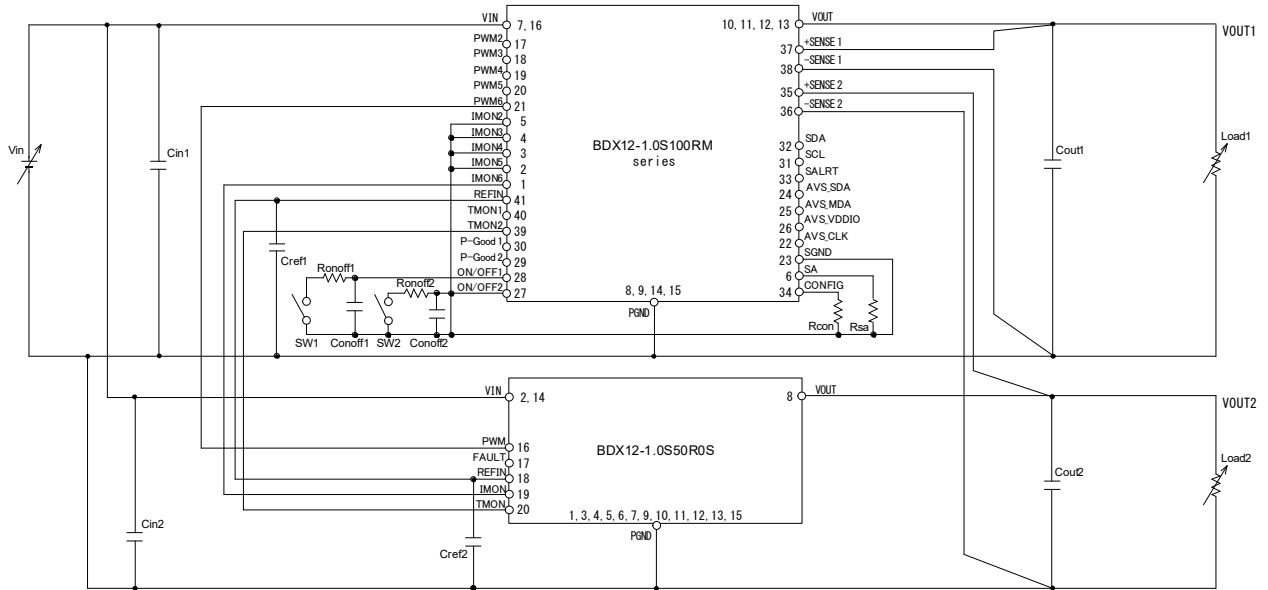
7-2 BDX12-1.0S100RM // BDX12-1.0S50R0S Parallel operation



Cin1: 22uF (3225 size Multi-layer ceramic capacitor) x 4,
 10uF (3216 size Multi-layer ceramic capacitor) x 4
 Cin2: 10uF (3216 size Multi-layer ceramic capacitor) x 4
 Cout1: 100uF (3216 size Multi-layer ceramic capacitor) x 8,
 47uF (2012 size Multi-layer ceramic capacitor) x 8
 Cout2: 100uF (3216 size Multi-layer ceramic capacitor) x 4
 Cref2: 0.1uF (1005 size Multi-layer ceramic capacitor)
 Rsa: Address setting resistor
 Rcon: Configuration ID setting resistor
 Ronoff1: 10Ω
 Conoff1: 0.1uF (1005 size Multi-layer ceramic capacitor)
 SW1 (VOUT1 ON/OFF contro)
 Open: Output ON
 Short: Output OFF

- Note 1: The default setting is set for single operation, so when parallel operation is required, setting writing by serial communication is necessary. Please refer to “BDX series Parallel, Dual output operation Application Note” for details about parallel operation, such as setting writing and using multiple BDX 12-1.0S50R0S.
- Note 2: SENSE line (the line from +SENSE1, -SENSE1 pin to the both sides of Cout1) is related to the feedback loop. Since the SENSE line is sensitive to noise, do not route the wiring long as much as possible and wire it in parallel.
- Note 3: IMON-REFIN line (the line from IMONx and REFIN pin of BDX12-1.0S100RM to IMON and REFIN pin of BDX12-1.0S50R0S) is strongly related to the feedback loop and current monitor accuracy. Since the IMON-REFIN line is sensitive to noise, do not route the wiring long as much as possible and wire it in parallel. Please refer to the layout commentary in "BDX series Evaluation Board User Manual" for handling the IMON-REFIN line.
- Note 4: Current signal reference voltage of 1.25V typ. is supplied to the REFIN line (the line from REFIN pin of BDX12-1.0S100RM to REFIN pin of BDX12-1.0S50R0S) from BDX12-1.0S100RM, and it is strongly related to current monitor accuracy. Since the REFIN line is sensitive to noise, insert a capacitor of Cref2 = 0.1uF on the BDX12-1.0S50R0S side. Also, make sure to keep the capacitance 20uF or less between REFIN and GND.
- Note 5: At the PWM line (the line from PWMx pin of BDX12-1.0S100RM to PWM pin of BDX12-1.0S50R0S) a square wave of 0↔3.3V typ., 600kHz typ. is transmitted. Be careful not to bring PWM line close to SENSE line, IMON - REFIN line, and to other noise sensitive lines. Also, be careful that the PWM line does not exceed 5V.

7-3 BDX12-1.0S50R0S Dual output operation



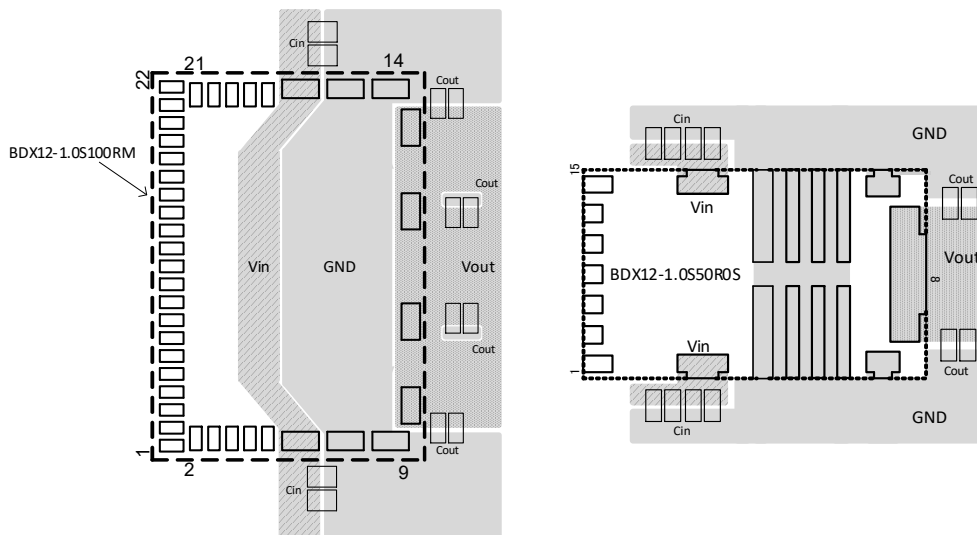
- | | | |
|--|--|--|
| <p>Cin1: 22uF (3225 size Multi-layer ceramic capacitor) x 4,
10uF (3216 size Multi-layer ceramic capacitor) x 4
Cin2: 22uF (3225 size Multi-layer ceramic capacitor) x 4,
10uF (3216 size Multi-layer ceramic capacitor) x 8
Cout1: 100uF (3216 size Multi-layer ceramic capacitor) x 8,
47uF (2012 size Multi-layer ceramic capacitor) x 8
Cout2: 100uF (3216 size Multi-layer ceramic capacitor) x 4,
47uF (2012 size Multi-layer ceramic capacitor) x 16,
1000uF (7343 size Conductive polymer capacitor) x 1</p> | <p>Cref1: 2.2uF (2012 size Multi-layer ceramic capacitor)
Cref2: 0.1uF (1005 size Multi-layer ceramic capacitor)
Rsa: Address setting resistor
Rcon: Configuration ID setting resistor
Ronoff1: 10Ω
Conoff1: 0.1uF (1005 size Multi-layer ceramic capacitor)</p> | <p>SW1 (VOUT1 ON/OFF control)
Open: Output ON
Short: Output OFF
SW2 (VOUT2 ON/OFF control)
Open: Output ON
Short: Output OFF</p> |
|--|--|--|

- Note 1: Make sure to connect the +SENSE_x and -SENSE_x pins to the converter.
- Note 2: The SENSE line (the line from +SENSE_x, -SENSE_x pin to the both sides of Cout_x) is related to the feedback loop. Since the SENSE line is sensitive to noise, do not route the wiring long as much as possible and wire it in parallel.
- Note 3: When wiring between SW_x and the converter is extended and connected, overshoot and undershoot may occur on the ON/OFF_x pin. In that case, please connect SW_x via RC filter (reference value: Ronoff_x = 10 Ω, Conoff_x = 0.1 μF).
- Note 4: The default setting is set for single operation, so when dual output operation is required, setting writing by serial communication is necessary. Please refer to “BDX series Parallel, Dual output operation Application Note” for details about parallel operation, such as setting writing and using along with parallel operation.
- Note 5: IMON-REFIN line (the line from IMON_x and REFIN pin of BDX-1.0S100RM to IMON and REFIN pin of BDX12-1.0S50R0S) is strongly related to the feedback loop and current monitor accuracy. Since the IMON-REFIN line is sensitive to noise, do not route the wiring long as much as possible and wire it in parallel.
Please refer to the layout commentary in "BDX series Evaluation Board User Manual" for handling the IMON-REFIN line.
- Note 6: Current signal reference voltage of 1.25V typ. is supplied to the REFIN line (the line from REFIN pin of BDX12-1.0S100RM to REFIN pin of BDX12-1.0S50R0S) from BDX12-1.0S100RM, and it is strongly related to current monitor accuracy. Since the REFIN line is sensitive to noise, insert a capacitor between REFIN and GND of Cref1 = 2.2uF on BDX12-1.0S100RM side and Cref2 = 0.1uF on BDX12-1.0S50R0S side. Also, make sure to keep the capacitance 20uF or less between REFIN and GND.
- Note 7: At the PWM line (the line from PWM_x pin of BDX12-1.0S100RM to PWM pin of BDX12-1.0S50R0S) a square wave of 0↔3.3V typ., 500kHz typ. is transmitted. Be careful not to bring PWM line close to SENSE line, IMON - REFIN line, and to other noise sensitive lines.
Also, be careful that the PWM line does not exceed 5V.

7-4 Recommended layout

Connect the VIN and VOUT pins of BDX12-1.0S100RM and BDX12-1.0S50R0S in a solid pattern in the vicinity of the converter pin (see reference layout below). The reference layout diagram below shows only the power lines on the mounting surface. Please design considering the current value and the environmental temperature etc. to be used.

Please refer to the layout commentary in "BDX series Evaluation Board User Manual" for detailed layout such as handling signal lines and using multiple units of BDX12-1.0S50R0S.

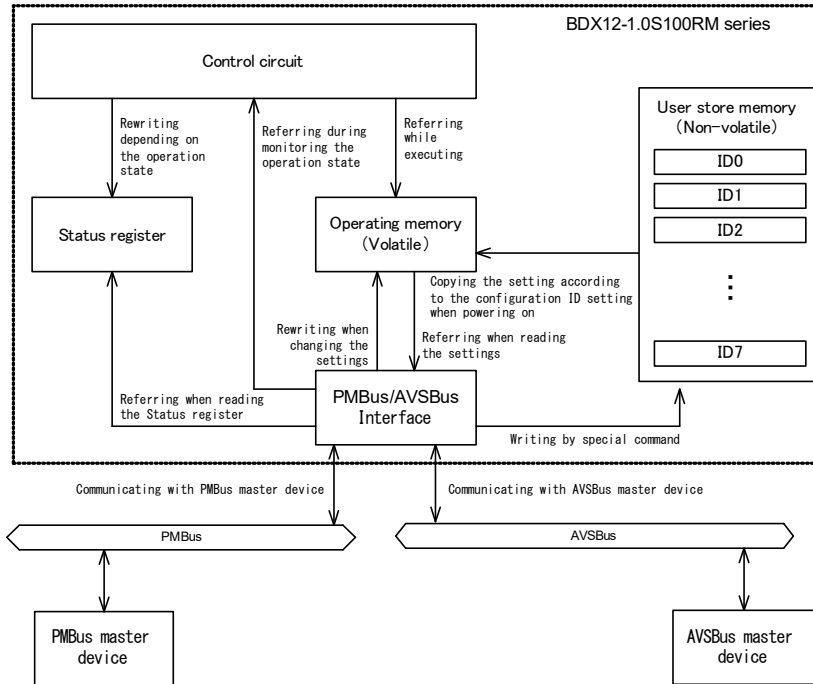


8. Functions

8-1 Digital control

The PMBus and AVSBus communication interface (serial communication) allows output voltage, sequence and other product settings to be changed and information such as input voltage and output voltage to be obtained.

Values configured via serial communication should be taken as the targeted ones which could differ from the actual values due to product variations.



Digital control conceptual diagram

8-1-1 Internal memory

The product contains volatile operating memory and non-volatile user store memory. Settings for the converter are stored in the user store memory and the settings are copied from the user store memory corresponding to the configuration ID setting resistor Rcon, to the operating memory during start-up.

Rcon [Ω]	Configuration ID
6800	0
1800	1
2200	2
2700	3
3300	4
3900	5
—	6 (unavailable)
5600	7 (standard setting, write disabled)

Control circuit of the product reads the contents of the operating memory. The contents can be re-written when the settings are changed via serial communication. Because the operating memory is volatile, the changed settings in this memory are lost when the product is turned off.

In order to change the setting value at start-up, it is necessary to write the setting value to the nonvolatile user store memory by the special command and connect the configuration ID setting resistor Rcon. You cannot rewrite and delete configuration ID once written. For information of special commands, please contact us.

8-2 Output voltage setup

This output voltage can be changed in the range between 500 to 1200mV only via serial communication, not via an external resistor. Output voltage other than the default setting can only be changed via serial communication.

Item	PMBus/AVSBus commands	Adjustment range	Resolution	Default setting
Output voltage	PMBus - VOUT_COMMAND	500 to 1200mV	1mV	1000mV
	AVSBus – TARGET_RAIL_VOLTAGE			

Note: When the output voltage setting is changed, the setting of turn-on rise and turn-off fall will not be maintained. Please reset the turn-on rise and turn-off fall.

8-3 Margin State

The product has 3 margin states, Margin OFF, Margin HIGH and Margin LOW when setting output voltage. Different output voltage can be set to each Margin state and the output voltage is adjusted to the value of the preset margin state at that time.

Output voltage can be set independently on each Margin State in the range between 500 to 1200mV via PMBus communication.

Items	PMBus commands	Adjustment range	Resolution	Default setting
Output voltage in the Margin OFF State	VOUT_COMMAND	500 to 1200mV	1mV	1000mV
Output voltage in the Margin High State	VOUT_MARGIN_HIGH	500 to 1200mV	1mV	1200mV
Output voltage in the Margin Low State	VOUT_MARGIN_LOW	500 to 1200mV	1mV	500mV

The default margin state setting is OFF.

The margin state can be switched to Margin High or Margin Low via PMBus communication when temporal voltage change is required.

Item	PMBus commands	Default setting
Switching Margin States	OPERATION	Margin OFF

8-4 Output voltage trimming

This function allows output voltage to be increased or decreased in the range mentioned below via PMBus communication.

Item	PMBus command	Setting range	Resolution	Default setting
Output voltage trimming	VOUT_TRIM	-250 to +250mV	1mV	0mV

8-5 Output voltage limit

This function enables output voltage to be set at the highest level that can be configured via the VOUT_COMMAND, VOUT_MARGIN_HIGH or VOUT_MARGIN_LOW commands.

It caps output voltage at the preset level in case of excessive output voltage accidentally being applied.

It has no connection with the overvoltage protection feature. The setting value of this function can be set via PMBus communication.

Item	PMBus command	Setting range	Resolution	Default setting
Output voltage max. value	VOUT_MAX	500 to 1200mV	1mV	1200mV
Output voltage min. value	VOUT_MIN	500 to 1200mV	1mV	500mV

8-6 Remote sensing

This function allows excellent load regulation characteristics to be obtained on the load side. The sensing line is a part of the feed back loop and is very sensitive, thus extra care must be exercised when routing a pattern. Route the +SENSE_x and –SENSE_x pins side by side and connect the pins to the load.

When this function is not used at VOUT1, make sure to connect between the VOUT and +SENSE1 pins as well as the PGND and –SENSE1 pins of BDX12-1.0S100RM. When this function is not used at VOUT2, make sure to connect between the VOUT and +SENSE2 pins as well as the PGND and –SENSE2 pins of BDX12-1.0S50R0S which is outputting VOUT2.

8-7 ON/OFF control

This function allows output voltage to be turned on and off without switching the input on or off physically. It can be controlled by two methods, one is using the ON/OFF_x pin and the other is by using the PMBus communication.

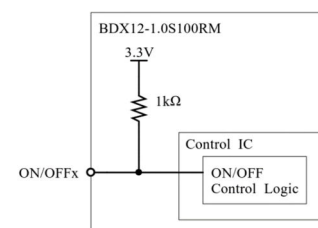
Each method can be set to “enabled” or “disabled” by PMBus communication. By default, the ON/OFF control by the ON/OFF_x pin is set “enabled”.

8-7-1 ON/OFF control via the ON/OFF_x pin

ON/OFF of VOUT1 and VOUT2 can be controlled by opening or short-circuiting between the ON/OFF1 pin and SGND pin, ON/OFF2 pin and SGND pin. As per the chart below, ON/OFF_x pin is pulled up to 3.3V internally via output resistance of 1kΩ.

Between the ON/OFF1 pin – SGND pin	Output	Remarks
OPEN (2.55V min.)	ON	Open circuit voltage of pin is 3.3V. (±0.1V) Output resistance 1kΩ (±1%, ±100ppm/K)
SHORT (0.8V max.)	OFF	Source current 3.5mA max.

Note: Make sure not to generate chattering between the ON/OFF_x pin and SGND pin.



8-7-2 ON/OFF control via PMBus communication

Output voltage can be controlled on or off via PMBus communication. When using PMBus communication to turn off output, switching can be terminated immediately or after a turn-off sequence has been applied.

Items	PMBus commands	Default settings
ON/OFF control via PMBus communication	OPERATION	Output OFF
Operation setting of ON/OFF control *1	ON_OFF_CONFIG	ON/OFF control – via ON/OFF _x pin in enabled ON/OFF control – via PMBus communication is disabled

*1 When both ON/OFF control by the ON/OFF_x pin and PMBus communication are enabled, AND operation is performed as shown in the table below.

Between ON/OFF _x pin - SGND pin	Settings by PMBus – OPERATION commands	Output settings
Open	ON	ON
Open	OFF	OFF
Short	ON	OFF
Short	OFF	OFF

8-8 Sequence setup

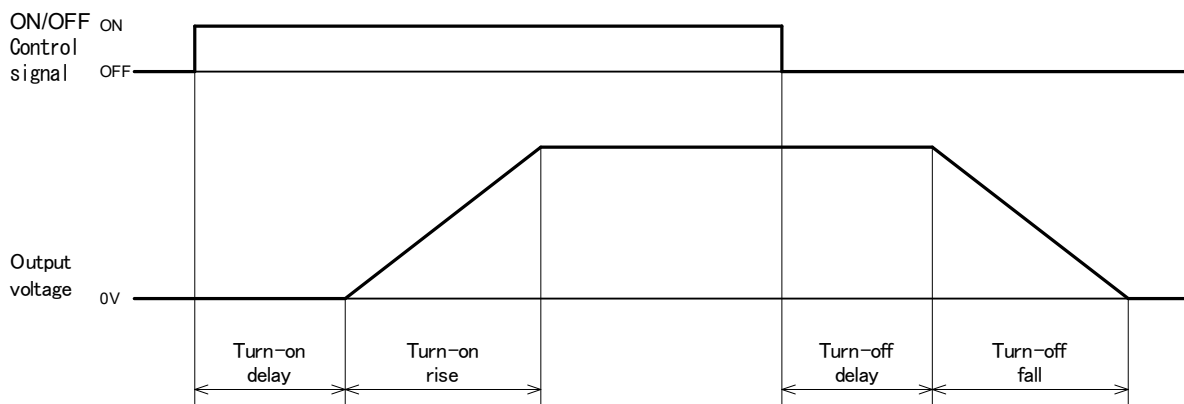
This function allows the items below to be configured.

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

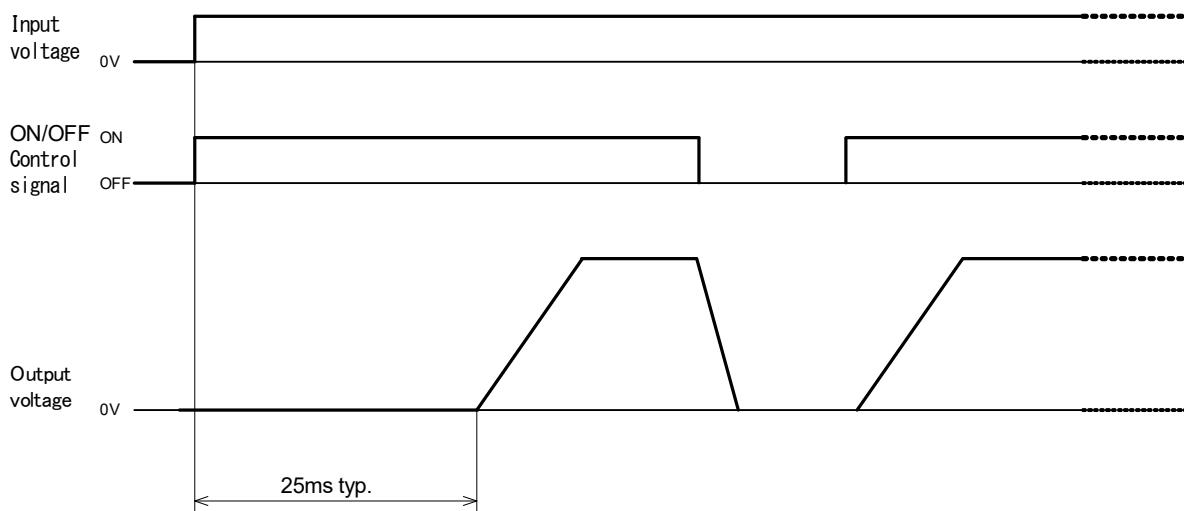
Turn-on delay is a period from when the ON command is issued by the ON/OFF control (via the ON/OFF1 pin or PMBus communication) until output voltage begins increasing. (See the figure below).

Turn-off delay is a period from when the OFF command is issued by the ON/OFF control (via the ON/OFF1 pin or PMBus communication) until output voltage begins decreasing. (See the figure below).

Turn-on Rise and Turn-off Fall are not retained when the output voltage setting is changed. Please reset Turn-on Rise and Turn-off Fall after changing the output voltage setting.



There is a delay of 25ms typ. until the turn-on sequence begins after the input. (See the figure below). Each setting of the sequence features can be configured via PMBus communication. However, turn-on rise may differ from the preset time depending on load capacity.



Items	PMBus commands	Setting range	Resolution	Default setting
Turn-on delay	TON_DELAY	0.2 to 50ms	0.01ms	0.2ms
Turn-on rise	TON_RISE	1.0 to 10ms	0.001ms	1.0ms
Turn-off delay	TOFF_DELAY	0.0 to 50ms	0.01ms	0.0ms
Turn-off fall	TOFF_FALL	1.0 to 10ms	0.001ms	1.0ms

Turn-off delay and turn-off fall do not apply when the converter is turned off by the following protection features (Under voltage lock out, Input overvoltage protection, Output overvoltage protection, Overcurrent protection).

8-9 Output voltage transition rate setting

This function allows output voltage transition rate to be configured via serial communication when changing output voltage.

Item	PMBus/AVSBus commands	Setting range	Resolution	Default setting
VOUT1 Output voltage transition rate setting value	PMBus - VOUT_TRANSITION_RATE	0.1 to 10mV/ μ s	0.1mV/ μ s	10mV/ μ s
	AVSBus - TRANSITION_RATE			
VOUT2 Output voltage transition rate setting value	PMBus - VOUT_TRANSITION_RATE	0.1 to 1mV/ μ s	0.1mV/ μ s	1mV/ μ s
	AVSBus - TRANSITION_RATE			

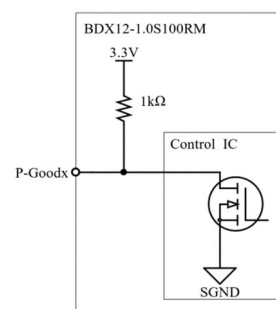
8-10 P-Good signal

P-Good1 and P-Good2 pins allow monitoring the status of VOUT1 and VOUT2 respectively.

As shown in the right figure, P-Goodx pin is pulled up to 3.3V internally via output resistance of 1k Ω .

P-Goodx pin outputs High when the converter is performing the assumed regulation, and Low when it is under the following conditions.

- When the output is set to OFF by ON/OFFx pin or PMBus communication
- During turn-on delay
- During turn-on rise
- When protection functions such as overcurrent protection, under voltage lock out, output overvoltage protection etc. are in operation



Note 1: P-Goodx pin may output High when input voltage turn-on up to operation starting voltage.

P-Goodx pin output	Pin voltage	Remarks
High	3.3V (± 0.1 V)	Output resistance 1k Ω ($\pm 1\%$, ± 100 ppm/K)
Low	0.4V max.	

8-11 Operation state monitoring

Input voltage, output voltage and output current of the product can be obtained via serial communication.

Items	Monitor accuracy	Conditions
Input voltage	$\pm 2.5\%$ typ.	Input voltage 12V
Output voltage	$\pm 0.5\%$ typ.	Output voltage 800mV or more, 1200mV or less
	± 5 mV typ.	Output voltage 500mV or more, less than 800mV
Output current	$\pm 5\%$ FS ^{*1} typ.	Input voltage 12V, output voltage 1.0V, ambient temperature 25°C

*1 Based on 100% output current.

This product contains 6 status registers, STATUS_BYTE, STATUS_WORD, STATUS_VOUT, STATUS_IOUT, STATUS_INPUT, STATUS_TEMPERATURE. Error status of this product can be detected by monitoring the status registers.

The status registers are set when the protection features are activated during operation. Either one of the items stated below can clear the status registers.

- Execute the CLEAR_FAULTS command
- Re-startup input
- During automatic reset operation

The contents of each register can be read out via serial communication. Refer to the command list for each register in details.

Items	PMBus/AVSBus commands
Monitoring input voltage	PMBus - READ_VIN
Monitoring output voltage	PMBus - READ_VOUT
Monitoring output current	PMBus - READ_IOUT
STATUS_BYTE register	PMBus - STATUS_BYTE
STATUS_WORD register	PMBus - STATUS_WORD
STATUS_VOUT register	PMBus - STATUS_VOUT
STATUS_IOUT register	PMBus - STATUS_IOUT
STATUS_INPUT register	PMBus - STATUS_INPUT
STATUS_TEMPERATURE register	PMBus - STATUS_TEMPERATURE
AVSBus STATUS register	AVSBus - AVSBus STATUS

8-12 Under Voltage Lock Out (UVLO)

This function prevents the product from malfunctioning when input voltage drops. When the input voltage becomes equal to or higher than the activation voltage, it prepares for switching operation to start and when the input voltage falls below the deactivation voltage it stops switching operation.

Note: The status register (See section 9-6-5 , 9-6-6 , 9-6-9) of UVLO may be set depending on voltage tilt in degrees during power-up.

8-13 Input overvoltage protection

Input voltage of 15V typ. or over activates the overvoltage protection feature that stops switching operation. Input voltage of 14V typ. or under restarts switching operation.

Note: Refrain from inputting voltage that exceeds 14V which is out of specification. Protection will not activate when input voltage exceeds 14V and under 15V.

8-14 Output overvoltage protection

When output voltage (between the +SENSE1 and –SENSE1 pins) exceeds operation threshold of the output overvoltage protection feature, switching operation stops (shut down).

This feature will not function if overvoltage state is caused due to breakage of the product.

Threshold of the output overvoltage protection can be configured via PMBus communication.

Item	PMBus command	Setting range	Resolution	Default setting
Threshold of output overvoltage protection	VOUT_OV_FAULT_LIMIT	500 to 1350mV	1mV	1350mV

Note 1: Applications that require sudden load current change may activate the output overvoltage protection depending on adjustment level of output voltage. To prevent this, output capacitors should be added.

Note 2: You can retry the turn-on sequence by one of the following methods.

- Execute the CLEAR_FAULTS command
- Turn ON after setting to OFF by ON/OFF control (See section 8-7).
- Re-startup input

8-15 Output overcurrent protection

When output goes into an overcurrent state, switching operation will cease and restarts turn-on sequence after 100ms typ. Upon releasing the overcurrent state, switching operation will resume with output voltage.

Note : Refrain from keeping an overcurrent state for a long time period.

9. PMBus communication

9-1 Definitions of Symbols and Terms

The symbols and terms used in section 9 are defined as below

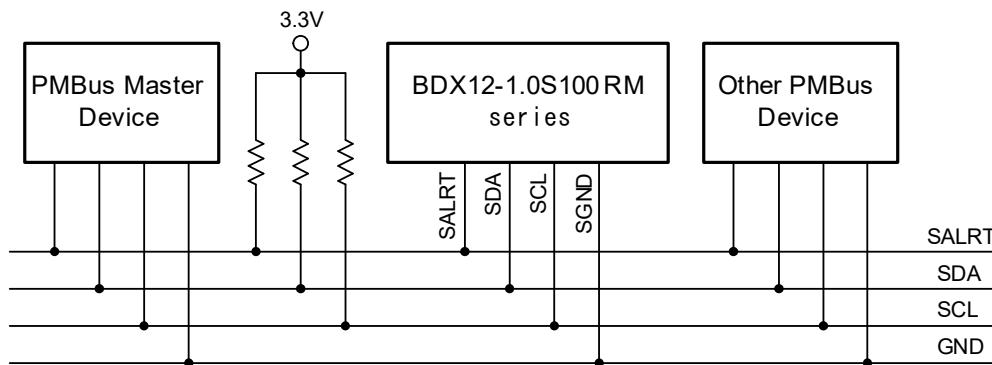
Symbols or Terms	Definition
Byte	8 bits
Word	16 bits (2 bytes)
Set	Set bit to logic "1"
Clear	Set bit to logic "0"
n nb	Number "nn" should be in a binary value
n nh	Number "nn" should be a value in hexadecimal notation

9-2 Communication method

PMBus interface of the product complies with PMBus Specification Revision 1.3.

9-3 Communication pins

The PMBus communication pins (SDA, SCL, SALRT) should be connected to a 3.3V power supply by using a pull-up resistor or its equivalent method.



9-3-1 SDA pin

The SDA pin is a data input/output pin used for PMBus communication. The pin serves as an open drain output when data is output.

- Input Low level: 0.8V max.
- Input High level: 1.55V min.
- Output Low level: 0.4V max. (Sink current 4mA max.)

9-3-2 SCL pin

The SCL pin is a clock input pin used for PMBus communication. The SCL pin does not get driven by the product but by a bus master device.

- Input Low level: 0.8V max.
- Input High level: 1.55V min.
- Input frequency: 50 to 1000 kHz

9-3-3 SALRT pin

The SALRT pin is an abnormal signal output pin which serves as an open drain output. The pin is open in normal mode and low in abnormal mode.

Output Low level: 0.4V max. (Sink current 4mA max.)

9-4 Device address setup

Each device can be identified by a device address since multiple devices share the same bus in the PMBus protocol. A unique device address should be given in order to avoid device address duplication on the same bus.

A device address can be specified by placing a resistor between the SA and SGND pins.

The following table shows resistor values(Rsa) and their corresponding device addresses. Each resistor should have a 1% tolerance (E12 standard).

A device address will be specified according to resistance value between the SA and SGND pins during power up. Thus input voltage requires to be set at 0V if you want to change a device address.

Even when the communication feature is not used, make sure the SA pin is NOT OPEN.

Device address	Rsa [Ω]	Device address	Rsa [Ω]
1100 000	0	1010 000	1500
1100 001	180	1010 001	1800
1100 100	330	1010 100	2200
1100 101	470	1010 101	2700
1000 000	680	1011 000	3300
1000 001	820	1011 001	3900
1000 100	1000	1011 100	4700
1000 101	1200	1011 101	5600

9-5 Data format

9-5-1 Direct Format

The data format comprises of elements indicated below.

X: Actual value

Y: Value using data word of the PMBus command
(A 2-byte signed integer using two's complement)

m: Tilt coefficient

b: Off set value

R: Exponential

* Refer to 9-6-1 for value of m, b, R.

The formula below shows links between the elements.

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

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

9-6 VPMBus commands

9-6-1 PMBus command list

The following PMBus commands can be used for this product.

1) VOUT1, VOUT2 in common

PMBus commands	Command codes	Transaction type**1	Data length (Byte)	Data format	Unit	Default setting
PAGE	00h	R/W Byte	1	—	—	00h
ON_OFF_CONFIG	02h	R/W Byte	1	—	—	16h
CLEAR_FAULTS	03h	Send Byte	0	—	—	—
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	—	—	—
READ_VIN	88h	Read Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	—
APPLY_SETTINGS	E7h	Write Word	2	—	—	—
RESTORE_CONFIG	F2h	Write Word	2	—	—	—

2) VOUT1

PMBus commands	Command codes	Transaction type ^{*1}	Data length (Byte)	Data format	Unit	Default setting
OPERATION	01h	R/W Byte	1	—	—	00h
VOUT_COMMAND	21h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	03E8h (1000mV)
VOUT_TRIM	22h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	0000h (0mV)
VOUT_MAX	24h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	04B0h (1200mV)
VOUT_MIN	2Bh	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	01F4h (500mV)
VOUT_MARGIN_HIGH	25h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	04B0h (1200mV)
VOUT_MARGIN_LOW	26h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	01F4h (500mV)
VOUT_TRANSITION_RATE	27h	R/W Word	2	Direct ($m = 1, b = 0, R = 1$)	mV / μ s	0064h (10mV/ μ s)
VOUT_OV_FAULT_LIMIT	40h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	0546h (1350mV)
TON_DELAY	60h	R/W Word	2	Direct ($m = 1, b = 0, R = 2$)	ms	0014h (0.20ms)
TON_RISE	61h	R/W Word	2	Direct ($m = 1, b = 0, R = 3$)	ms	03E8h (1.000ms)
TOFF_DELAY	64h	R/W Word	2	Direct ($m = 1, b = 0, R = 2$)	ms	0000h (0.00ms)
TOFF_FALL	65h	R/W Word	2	Direct ($m = 1, b = 0, R = 3$)	ms	03E8h (1.000ms)
READ_VOUT	8Bh	Read Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	—
READ_IOUT	8Ch	Read Word	2	Direct ($m = 0.5, b = 0, R = 1$)	A	—

3) VOUT2

PMBus commands	Command codes	Transaction type ^{*1}	Data length (Byte)	Data format	Unit	Default setting
OPERATION	01h	R/W Byte	1	—	—	00h
VOUT_COMMAND	21h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	03E8h (1000mV)
VOUT_TRIM	22h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	0000h (0mV)
VOUT_MAX	24h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	04B0h (1200mV)
VOUT_MIN	2Bh	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	01F4h (500mV)
VOUT_MARGIN_HIGH	25h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	04B0h (1200mV)
VOUT_MARGIN_LOW	26h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	01F4h (500mV)
VOUT_TRANSITION_RATE	27h	R/W Word	2	Direct ($m = 1, b = 0, R = 1$)	mV / μ s	000Ah (1mV/ μ s)
VOUT_OV_FAULT_LIMIT	40h	R/W Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	0546h (1350mV)
TON_DELAY	60h	R/W Word	2	Direct ($m = 1, b = 0, R = 2$)	ms	0014h (0.20ms)

TON_RISE	61h	R/W Word	2	Direct ($m = 1, b = 0, R = 3$)	ms	03E8h (1.000ms)
TOFF_DELAY	64h	R/W Word	2	Direct ($m = 1, b = 0, R = 2$)	ms	0000h (0.00ms)
TOFF_FALL	65h	R/W Word	2	Direct ($m = 1, b = 0, R = 3$)	ms	03E8h (1.000ms)
READ_VOUT	8Bh	Read Word	2	Direct ($m = 1, b = 0, R = 0$)	mV	—
READ_IOUT	8Ch	Read Word	2	Direct ($m = 1/3, b = 0, R = 1$)	A	—

*1) The proper names of data formats in the transaction type indicated in the previous page are described below.

Transaction type	Communication protocol
Send Byte	Send Byte Protocol
Read Byte	Read Byte Protocol
Read Word	Read Word Protocol
Write Word	Write 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 is used for switching control objects of commands which are described in 9-6-1 -2) 3).

Meanings of each bit are described as below.

Bit No.	Purpose	Value	Description	Default setting
7-0	To switch the separate commands of VOUT1, VOUT2 control object	00000000	VOUT1	●
		00000001	VOUT2	

9-6-3 ON_OFF_CONFIG command (02h)

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

Meanings of each bit are described below.

Bit No.	Purpose	Value	Description	Default setting
7-5	—	000	Unavailable	●
4-2	To select “ENABLE” or “DISABLE” of the ON/OFF control	000	Select “Disable” of the ON/OFF control via PMBus communication and ON/OFF1 pin (Always set to ON)	●
		101	“Enable” ON/OFF1 pin, “Disable” PMBus communication	
		110	“Disable” ON/OFF1 pin, “Enable” PMBus communication	
		111	“Enable” ON/OFF1 pin and PMBus Communication *1	
1	—	1	Positive logic (Output is ON when opened)	●
0	To select “ENABLE” or “DISABLE” of turn-off sequence when output is turned off via the ON/OFF1 pin	0	Output is turned off via a sequence configured by TOFF_DELAY and TOFF_FALL.	●
		1	Switching stops immediately	

*1 ON/OFF control by ON/OFF1 pin, PMBus communication is AND operation (see 8-7-2).

9-6-4 CLEAR_FAULTS command (03h)

This is a command to clear all the bits in a status register. If executed after the output overvoltage protection function is activated, the turn-on sequence will be retried.

This command is used only to clear all the bits in a status register therefore contents of the status register remains until the causes are removed.

9-6-5 STATUS_BYTE command (78h)

This command is used to read the STATUS_BYTE register.

Meanings of each bit are described below.

Bit No.	Bit name	Description
7	—	Undisclosed
6	OFF	1 when output is OFF (OFF by protection features as well as the ON/OFF control)
5	VOUT_OV_FAULT	1 when overvoltage protection is activated
4	IOUT_OC_FAULT	1 when overcurrent protection is activated (0 during retry of turn-on sequence)
3	VIN_UV	1 when under voltage lock out is activated
2	—	Undisclosed
1	—	Undisclosed
0	—	Undisclosed

9-6-6 STATUS_WORD command (79h)

This command is used to read the STATUS_WORD register.

Meanings of each bit are described below.

Bit No.	Bit name	Description
15	VOUT	1 when one of the STATUS_VOUT register bits is 1
14	IOUT	1 when one of the STATUS_IOUT register bits is 1
13	INPUT	1 when one of the STATUS_INPUT register bits is 1
12	—	Undisclosed
11	POWER_GOOD#	Negative logic signal. 1 under conditions that P-Good pin becomes low.
10	—	Undisclosed
9	—	Undisclosed
8	—	Undisclosed
7	—	Undisclosed
6	OFF	1 when output is OFF (OFF by protection features as well as the ON/OFF control)
5	VOUT_OV_FAULT	1 when output overvoltage protection is activated
4	IOUT_OC_FAULT	1 when output overcurrent protection is activated (0 during retry of turn-on sequence)
3	VIN_UV	1 when under voltage lock out is activated
2	—	Undisclosed
1	—	Undisclosed
0	—	Undisclosed

9-6-7 STATUS_VOUT command (7Ah)

This command is used to read the STATUS_VOUT register.

Meanings of each bit are described below.

Bit No.	Description
7	1 when output overvoltage protection is activated
6-0	Undisclosed

9-6-8 STATUS_IOUT command (7Bh)

This command is used to read the STATUS_IOUT register.

Meanings of each bit are described below.

Bit No.	Description
7	1 when output overcurrent protection is activated (0 during retry of turn-on sequence)
6-0	Undisclosed

9-6-9 STATUS_INPUT command (7Ch)

This command is used to read the STATUS_INPUT register.

Meanings of each bit are described below.

Bit No.	Description
7	1 when input overvoltage protection is activated
6	Undisclosed
5	Undisclosed
4	1 when under voltage lock out is activated
3	Undisclosed
2	Undisclosed
1	Undisclosed
0	Undisclosed

9-6-10 READ_VIN command (88h)

This command is used to read input voltage.

9-6-11 APPLY_SETTINGS command (E7h)

This command is to apply the change contents after changing the setting of a specific command.

After changing the setting of the commands below, it is necessary to write 0001h with the APPLY_SETTINGS command.

VOUT_TRANSITION_RATE
VOUT_OV_FAULT_LIMIT
TON_RISE
TOFF_FALL

9-6-12 RESTORE_CONFIG command (F2h)

This command copies the setting value of the user store memory to the operating memory.

Meanings of each bit are described below.

Bit No.	Purpose	Value	Description
7-4	—	0h	Unavailable
3-0	Specify Configuration ID (Refer to 8-1-1)	0h	Configuration ID 0
		1h	Configuration ID 1
		2h	Configuration ID 2
		3h	Configuration ID 3
		4h	Configuration ID 4
		5h	Configuration ID 5
		7h	Configuration ID 7

9-6-13 OPERATION command (01h)

This command is used for the ON/OFF control and to select the output voltage command to be used. Meanings of each bit are described below.

Bit No.	Purpose	Value	Description	Default setting
7-6	ON/OFF control	00	Switching stops immediately	•
		01	Output is turned off via a sequence configured by TOFF_DELAY and TOFF_FALL	
		10	Output ON	
5-2	Select the output voltage command to be used	0000	PMBus - VOUT_COMMAND command (Margin OFF)	•
		0110	PMBus - VOUT_MARGIN_LOW command (Margin Low)	
		1010	PMBus - VOUT_MARGIN_HIGH command (Margin High)	
		1110	AVSBus - TARGET_RAIL_VOLTAGE command	
1	Copy of AVSBus - TARGET_RAIL_VOLTAGE command value	1	When the output voltage setting has been changed by AVSBus - TARGET_RAIL_VOLTAGE command, the setting value of TARGET_RAIL_VOLTAGE will be copied to PMBus - VOUT_COMMAND command value.	
		0	Do not change command value of PMBus - VOUT_COMMAND	•
0	—	0	Unavailable	•

A bit combination other than one of those specified above is not defined.

If the ON/OFF control is disabled via PMBus communication using the ON_OFF_CONFIG command, the ON/OFF feature can not be controlled via this command.

9-6-14 VOUT_COMMAND command (21h)

This command is used to configure output voltage when Margin state is Margin OFF.

9-6-15 VOUT_TRIM command (22h)

This command is used to set output voltage trimming.

9-6-16 VOUT_MAX command (24h)

This command is used to set a maximum limit of output voltage.

9-6-17 VOUT_MIN command (2Bh)

This command is used to set a minimum limit of output voltage.

9-6-18 VOUT_MARGIN_HIGH command (25h)

This command is used to set output voltage when Margin state is Margin High.

9-6-19 VOUT_MARGIN_LOW command (26h)

This command is used to set the output voltage when Margin state is Margin Low.

9-6-20 VOUT_TRANSITION_RATE command (27h)

This command is used to set the output voltage change rate during operation.

After writing this command, it is necessary to write 0001h with the APPLY_SETTINGS command (See section 9-6-11).

9-6-21 VOUT_OV_FAULT_LIMIT command (40h)

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

After writing this command, it is necessary to write 0001h with the APPLY_SETTINGS command (See section 9-6-11).

9-6-22 TON_DELAY command (60h)

This command is used to set turn-on delay.

9-6-23 TON_RISE command (61h)

This command is used to set turn-on rise.

After writing this command, it is necessary to write 0001h with the APPLY_SETTINGS command (See section 9-6-11).

9-6-24 TOFF_DELAY command (64h)

This command is used to set turn-off delay.

9-6-25 TOFF_FALL command (65h)

This command is used to set turn-off fall.

After writing this command, it is necessary to write 0001h with the APPLY_SETTINGS command (See section 9-6-11).

9-6-26 READ_VOUT command (8Bh)

This command is used to read output voltage.

9-6-27 READ_IOUT command (8Ch)

This command is used to read output current.

10. AVSBus communication

10-1 Definitions of Symbols and Terms

The symbols and terms used in section 10 are defined as below.

Symbols or 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" should be in a binary value
nnh	Number "nn" should be a value in hexadecimal notation

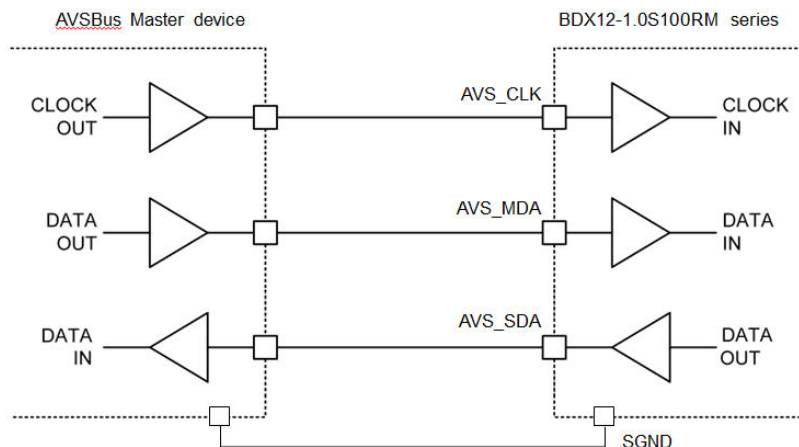
10-2 Communication method

AVSBus interface of this product complies with PMBus Specification Revision 1.3 – Part III (AVSBus).

10-3 Communication pins

Connect the AVSBus communication pins (AVS_CLK, AVS_MDA, AVS_SDA) to the AVSBus master device as shown below (AVSBus 3 - Wire Mode Connections).

Also, please connect the reference voltage pin AVS_VDDIO to a power supply of 0.9 to 3.63V.



10-3-1 AVS_MDA pin

The AVS_MDA pin is a data input pin used for AVSBus communication.

Input High level threshold: $0.6V \times AVS_VDDIO$ min.

Input Low level threshold: $0.4V \times AVS_VDDIO$ max.

10-3-2 AVS_CLK pin

The AVS_CLK pin is a clock input pin used for AVSBus communication.

The AVS_CLK pin does not get driven by the product but by the AVSBus master device.

Input High level threshold: $0.6V \times AVS_VDDIO$ min.

Input Low level threshold: $0.4V \times AVS_VDDIO$ max.

Input frequency: 5 to 50 MHz

10-3-3 AVS_SDA pin

The AVS_SDA pin is a data input pin of push-pull output.

Output High level: $0.8V \times AVS_VDDIO$ min.

Output Low level: $0.2V \times AVS_VDDIO$ max.

10-4 AVSBus commands

10-4-1 AVSBus command list

The AVSBus commands shown below can be used for this product.

AVSBus commands	<CmdDataType>	<Cmd>	<RailSel>
TARGET_RAIL_VOLTAGE	0000b	11b: Read 00b: Write	0000b: VOUT1 0001b: VOUT2
TRANSITION_RATE	0001b	11b: Read 00b: Write	0000b: VOUT1 0001b: VOUT2
RAIL_CURRENT	0010b	11b: Read	0000b: VOUT1 0001b: VOUT2
VOLTAGE_RESET	0100b	00b: Write	0000b: VOUT1 0001b: VOUT2
AVSBUS_STATUS	1110h	11b: Read	0000b

10-4-2 TARGET_RAIL_VOLTAGE command (0000b)

This command is used for setting the output voltage.

In order to control the output voltage with this command, it is necessary to set the output voltage command used in the PMBus - OPERATION command to the AVSBus – TARGET_RAIL_VOLTAGE (See section 9-6-13).

The <CmdData> field is a 16 bit unsigned integer (unit: mV).

10-4-3 TRANSITION_RATE command (0001b)

This command is used to set the output voltage transition rate during operation.

Meanings of each bit of the <CmdData> field are described below.

Bit No.	Purpose	Value
15-8	Setting transition rate when output voltage rises	8 bit unsigned integer (Unit: mV/ μ s)
7-0	Setting transition rate when output voltage drops	8 bit unsigned integer (Unit: mV/ μ s)

10-4-4 RAIL_CURRENT command (0010b)

This command is used to read the output current.

The <CmdData> field is a 16 bit unsigned integer (VOUT1 unit: 20×mA, VOUT2 unit: 30×mA).

10-4-5 VOLTAGE_RESET command (0100b)

This command will copy PMBus - VOUT_COMMAND command value to TARGET RAIL VOLTAGE command value.

The <CmdData> field should be 0000h.

10-4-6 AVSBUS_STATUS command (1110b)

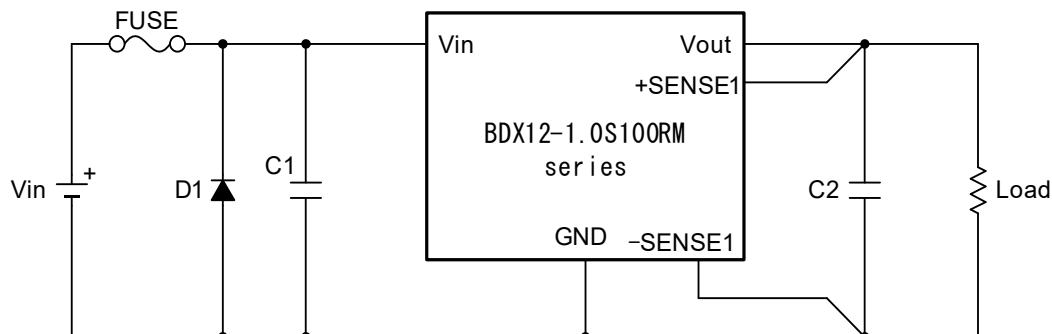
This command is used to read the AVSBUS_STATUS register. AVSBUS_STATUS register is common to VOUT1 and VOUT2.

Meanings of each bit of the <CmdData> field are described below.

Bit No.	Bit name	Description
15	VDONE	1 when output voltage reaches the output voltage setting
14-0	—	Undisclosed

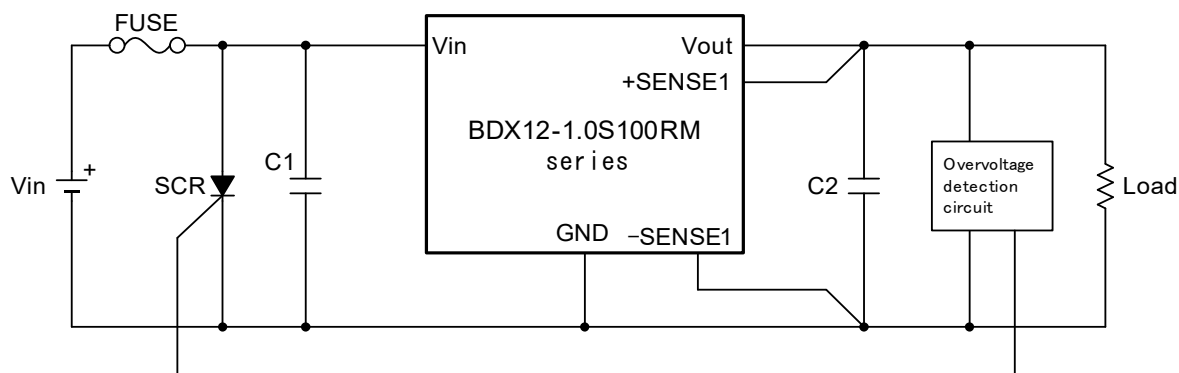
11. Reverse polarity protection at the input (Example)

Inadvertently, reversing the polarity of the input connected to the product can lead to product damage. If there is a possibility that the polarity reversal may occur, add a protection circuit to the product. The figure below is an example of a protection circuit using a fuse and diode.



12. Overvoltage protection (Example)

The product comes with a built-in overvoltage protection function. However, if switch element in the product is damaged when in short circuit mode, the DC input voltage might still be delivered directly to the output side. Thus, an input shutoff circuit needs to be added to the product to prevent it from becoming damaged when in overvoltage mode.



Note1: If the converter is damaged when in overvoltage mode, the ON/OFF control can not be operated.

Note2: If there is an ON/OFF feature for power source of the converter, the function can be used.

Note3: Allow enough capacity in the DC power supply for a fuse to blow.

13. Mounting requirements

The following conditions will apply to soldering temperature, time and storing before mounting.

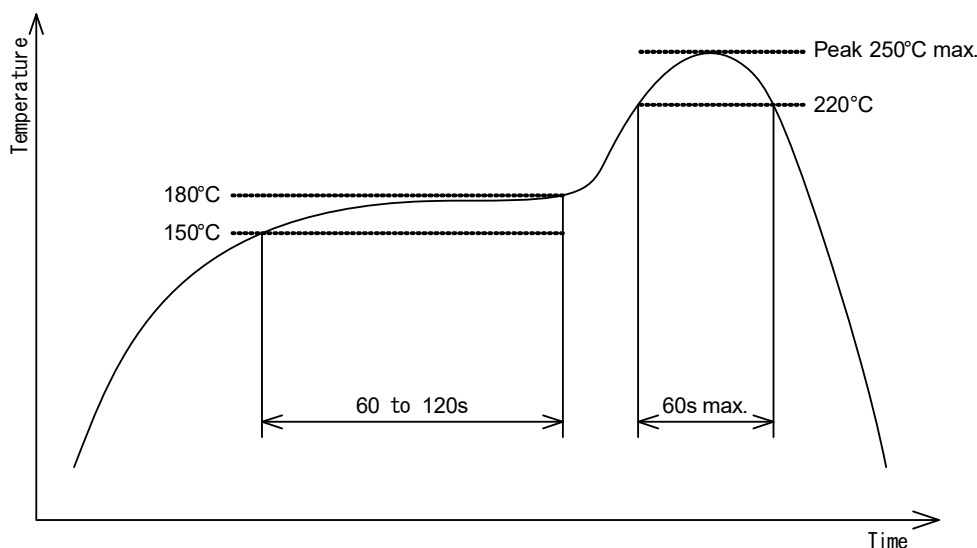
Re-flow method

- Pre-heat temperature: 150 to 180°C, 120s max. (See the figure below)
- Peak temperature: 250°C max.
220°C or over, 60s max.
- BDX12-1.0S100RM Re-flow count: Once

After mounting the converter onto a board, reflow can not be made again by turning over the mounted boards.

- BDX12-1.0S50R0S Re-flow count: Twice

Refrain from giving vibrations during reflow, for it may cause converter components to move. Flow mounting is not possible for the product.



13-1 Storage before mounting

Humidity control level for the product is JEDEC MSL3.

If a dry pack is opened, store at an ambience below 30°C/60%R.H.

If the product is kept in an unopened package for one year or kept in an opened dry package at an ambience below 30°C/60%R.H. for more than 168 hours, baking (125°C±5°C/24h) is required before reflow process.

After mounting the product, handle it in accordance with the storage requirements.

14. Vibration and Shock Testing

Vibration: 5 to 10Hz, Total amplitude 10mm, 10 to 55Hz, Acceleration 2G (One hour for each of the three directions)

Shock: Acceleration 20G (three times for each of the three directions), Shock time 11 ± 5ms

15. Cleaning

The product is not for immersible cleaning. Use of no-clean flux is recommended.

16. Precautions for use

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

- The product is intended for use in general electronics equipment (office equipment, communication equipment, measurement equipment). Do not use the product for medical equipment, nuclear equipment, trains, etc., whereby human life or property may be directly affected by a damaged product. Consult with us for any use other than for such general electronics equipment
- Minor changes and component parts changes that do not affect contents of the specifications will be made due to characteristic improvement of the product and other reasons without prior notice.
- The product is not suitable for series operation.
- Do not use connectors and sockets for mounting the product. Contact resistance may have an adverse effect on the performance. Use soldering method for mounting on a printed circuit board.
- The product supports for high current. Pattern or wiring can become higher temperature when current gets large. Current value must take sufficient measures when setting an evaluation environment and when designing the surrounding layout etc.
- The product has a built-in overcurrent protection circuit but avoid a prolonged short circuit state which may lead to failure.
- The product may be damaged if used under nonstandard electrical conditions or nonstandard environmental conditions including temperature. Ensure use within the standards.
- Avoid storing or using the product in a place that generates corrosive gas or dust.
- The product may be damaged by static electricity. Make sure that the workplace is guarded against static buildup and static electricity on operators by use of proper grounding.
- A fuse mechanism is not built in the product. Connect a fuse to the + input line to guard against excessive input current under abnormal circumstances. Allow enough capacity in the power supply for a fuse to blow.
- The product has overvoltage protection. If overvoltage occurs due to abnormality in the module, input voltage is output, as is, in the same mode, which may result in fumes and ignition. Make sure that an overvoltage protection circuit is added to prevent it from occurring.
- The product does not come with a test report.
- The product is subject to the license from Power-one which is related to the patented digital power technology owned by Bel Fuse Inc.

17. Warranty

The warranty term of the product is one year after shipment. Should the product become defective within the warranty period due to our design or workmanship, the product will be repaired free of charge or replaced. However, this warranty does not cover products which have been subjected to unauthorized inner modifications, etc.

The scope of our warranty is limited to that of the said product.

18. Contact

If you have any further technical questions for this product, please contact us.

E-mail: info@bellnix.com

URL: <http://www.bellnix.com>