Bellnix® BDA Series

This product is a 1.2V 25A 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) during operation. It also provides high-speed response suited as the power supply for critical devices such as FPGAs.

■ Features

- Output Voltage Accuracy ±1%
- High-Speed Response
- Small foot print, high power density
- Non-Isolated Converter
- Overcurrent protection
- Under Voltage Lock Out
- ON/OFF Control
- Adjustable Output Voltage (via external resistor or PMBus)
- Output Overvoltage Protection
- Settings can be changed and monitored during operation via serial communication (PMBus)
- Turn-on and turn-off sequences can be configured (via PMBus)
- High reliability, High performance
- SMD package
- Operating temperature −40ºC to +85ºC (Temperature derating required)
- RoHS compliant (2011/65/EU and (EU) 2015/863)

■ Model

Table 1 *1

Models BDA Series	Input V Vdc	Output V Vdc	Output I A	Line Reg. %(typ.)	Load Reg. %(typ.)	Noise mVpp(typ.)	Efficiency %(typ.)
BDA12-1.2S25R0	12 (8.0 to 14.0)	1.2 (0.5 to 1.2)	0 to 25 *3	0.2	0.2	20 *2	90 *4

*1 Unless otherwise specified, the product is measured at input voltage 12V, output voltage 1.2V, output current 25A, ambient temperature 25ºC±5ºC.
*2 BW = 20MHz
*3 Depending on ambient temperature, temperature derating and forced air cooling may be required.
*4 The product is measured at input voltage 12V, output voltage 1.2V, output current 12.5A, ambient temperature 25ºC±5ºC.

■ Specification

Table 2

Input voltage range	8.0 to 14.0V
Nominal input voltage	12V
Nominal output voltage	1.2V
Adjustable output voltage range	0.5 to 1.2V
Output current	0 to 25A, Dependent on ambient temperature derating and forced air cooling may be required.
Output voltage accuracy	±1% max.
Line regulation	0.2% typ. (Rated output, Input voltage varying from 8.0 to 14.0V)
Load regulation	0.2% typ. (Rated I/O voltage, output current varying from 0 to 100%)
Ripple noise	20mVpp typ. (Rated input/output, measurement frequency bandwidth 20MHz)
Efficiency	90% typ. (Rated I/O voltage, output current 50%)
Overcurrent protection	Yes
Under voltage lock out	Yes
Output overvoltage protection	Yes
Remote ON/OFF control	Yes
P-Good signal	Yes
Remote sensing	Yes
Operating temperature range	−40ºC to +85ºC (Refer to temperature derating described separately)
Storage temperature range	−40ºC to +85 ºC
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	2.4g typ.
Outer dimensions	W=27.0 L=16.5 H=4.0（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 DC-DC converter, BDA12-1.2S25R0.

2. Model/Rating

Model Name	Nominal input voltage	Rated output	Shape	Remarks
BDA12-1.2S25R0	DC 12.0V	DC 1.2V, 25A	SMD	

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.

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 compliant with RoHS Directive 2011/65/EU and amendment (EU) 2015/863.

4-1 Input characteristics

Items	Specifications & Standards	Conditions
Input voltage	8.0 to 14.0V (12.0V nominal)	
Input current	2.9A typ.	Input voltage 12.0V, output voltage 1.2V, output current 25A

4-2 Output characteristics and functions

*1, *2

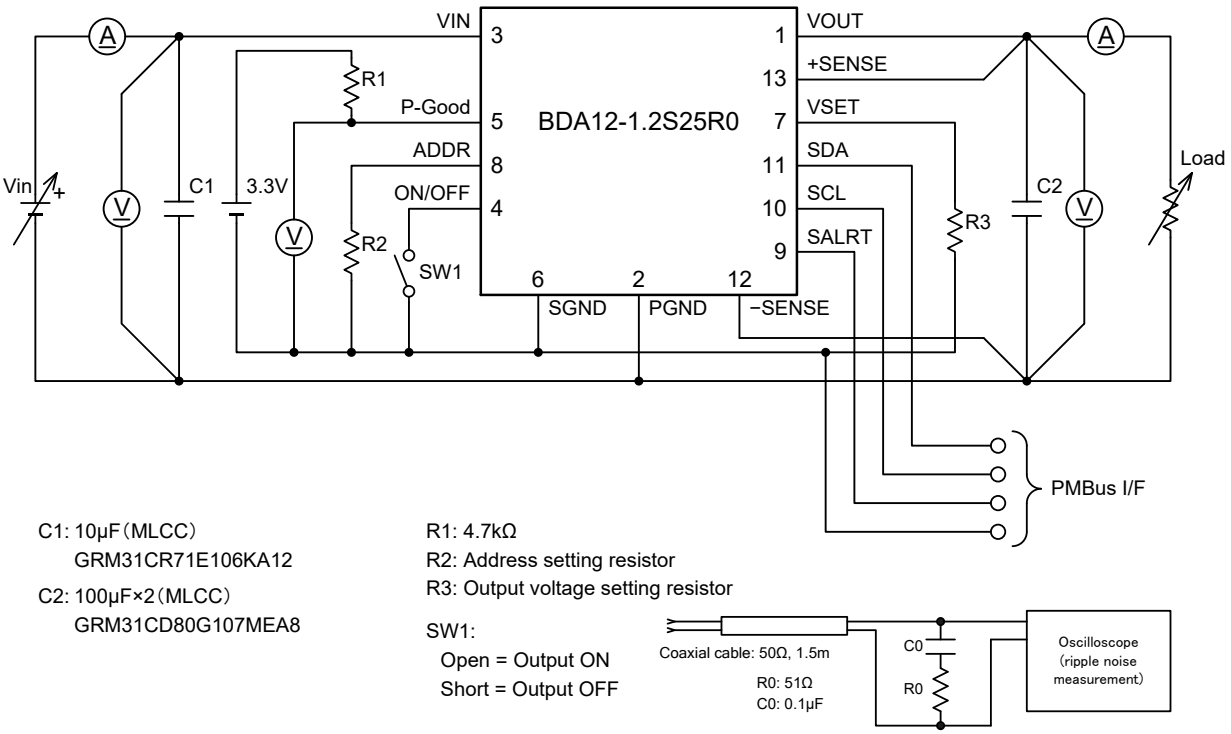
Items	Specifications & Standards	Conditions
Rated output voltage	1.2V	
Output voltage tolerance	±1% max.	Output current at 0% Ambient temperature −40 to +85°C
Output voltage range	0.5 to 1.2V	Configured via external resistor or serial communication
Output current	0 to 25A	Derating required
Line regulation	0.2% typ. 0.5% max.	Input varying from 8.0 to 14.0V
Load regulation	0.2% typ. 0.5% max.	Output current varying from 0 to 25A
Temperature regulation	±0.01%/°C typ.	Temperature varying from −40 to +85°C
Ripple noise	20mVp-p typ. 50mVp-p max.	BW = 20MHz
Efficiency	90% typ.	Output current at 12.5A
	87% typ.	Output current at 25A
Overcurrent protection	Operates at 105% or above (auto recovery)	Refer to section “8-14” for operation
Maximum output capacitance	4000μF	*3
Under Voltage Lock Out	Yes Activation voltage: 7.5V typ. Deactivation voltage: 7.0V typ.	Refer to section “8-11” for operation.
ON/OFF control	Between ON/OFF pin–SGND pin ON when open OFF when short circuit or low	Refer to section “8-6-1” for voltage at open and low. Control logic can be changed via serial communication. ON/OFF control possible via serial communication.
P-Good signal output	At normal output: Open At abnormal output: Low	Refer to section “8-9” for more information.
Output overvoltage protection	Yes	Shut down
Thermal protection	Yes	Shut down
Serial communication function	PMBus 1.3 compliance	
Sequence feature	Yes	Via serial communication
Monitoring feature	Yes	Via serial communication

*1 With measurement circuit of section “4-3”.

*2 Unless otherwise specified, measured at Input voltage of 12.0V, output voltage of 1.2V, output current of 25A and ambient temperature of 25°C±5°C.

*3 Maximum output capacitance depends on the output voltage and turn-on time at 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 beyond specified maximum capacitance.

4-3 Measurement circuit



C1: 10μF（MLCC）
GRM31CR71E106KA12

C2: 100μF×2（MLCC）
GRM31CD80G107MEA8

R1: 4.7kΩ
R2: Address setting resistor
R3: Output voltage setting resistor

SW1:
Open = Output ON
Short = Output OFF

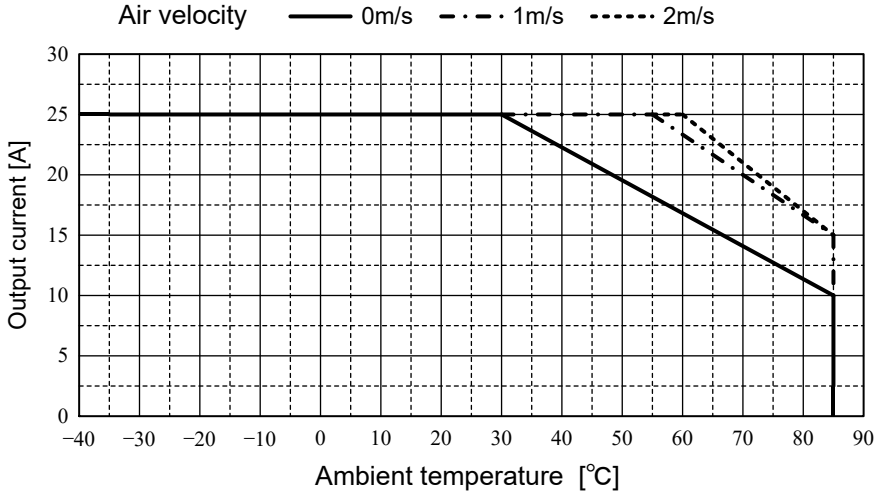
5. Temperature derating

Be sure to use this product on PCB with proper cooling. Also, be sure to mount it on the board before use. This product is designed to radiate heat using the mounted board.

Implement derating appropriate to usage environment.

Required derating shall be determined by ambient temperature and input voltage.

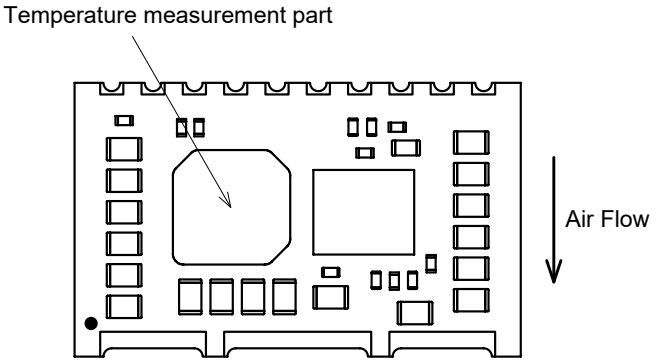
Temperature of the converter substantially varies depending on the board it is mounted on and on the ambient temperature. Ultimately, the component described below on actual equipment or system should not exceed 112.5°C at max. operating temperature.



<I/O voltage condition>
-Input voltage 12V
-Output voltage 1.0V

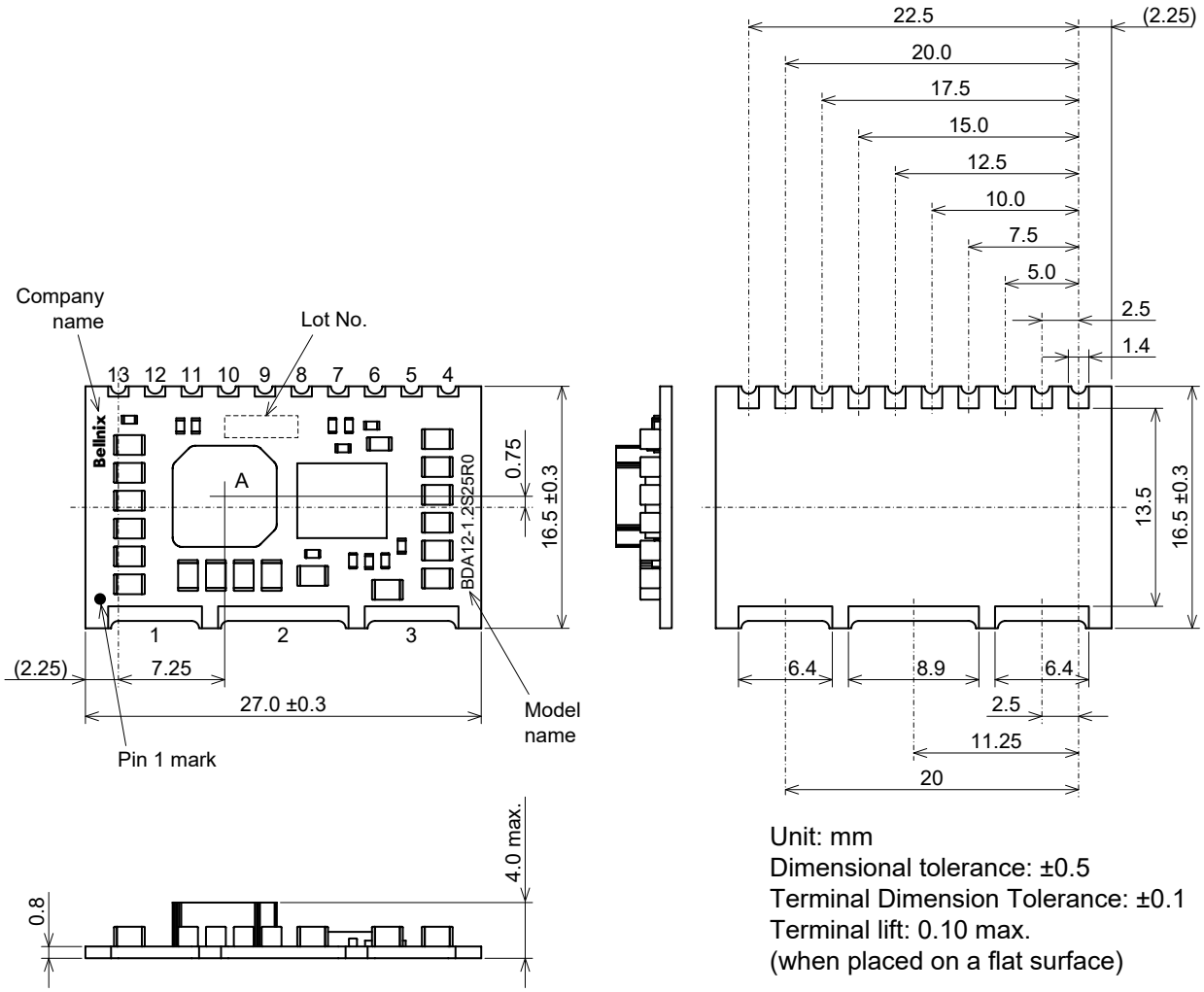
<Heat radiation pattern conditions>
100 x 100 mm copper area with 70um thickness when mounted on a 4 layered board.
(Only BDA12-1.2S25R0 is mounted)

<Air-flow direction, Temperature measurement conditions>



6. Outer dimensions and description of pins

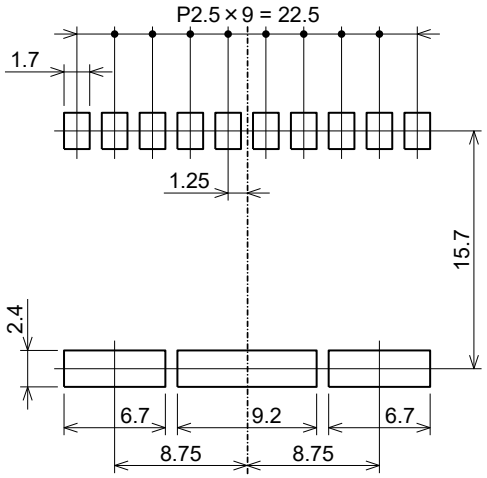
6-1 Shape and dimensions



Unit: mm
Dimensional tolerance: ±0.5
Terminal Dimension Tolerance: ±0.1
Terminal lift: 0.10 max.
(when placed on a flat surface)

Please lift up Position A if this product is mounting by surface mounter.

6-2 Recommended footprint



Unit: mm

Note 1) The dimensions shown left are recommended. Please take into account your company's design standard when designing.

Note 2) Do not route patterns underneath the converter. If there is a pin hole in the resist area, short circuit or the other problems may occur.

6-3 Description of pins

Pin	Name	Function
1	VOUT	Output
2	PGND	Power ground. Internally connected to SGND.
3	VIN	Power input
4	ON/OFF	Remote ON/OFF input
5	P-Good	Power Good signal output
6	SGND	Signal ground. Internally connected to PGND.
7	VSET	Output voltage setting
8	ADDR	Address setting
9	SALRT	PMBus alarm output
10	SCL	PMBus clock input
11	SDA	PMBus data I/O
12	−SENSE	Negative-side remote sensing *1
13	+SENSE	Positive-side remote sensing *1

*1 As it is the pin related to feedback loop, needs to be carefully handled in particular. Be sure to refer to chapter “7” and section “8-5” when handling.

6-4 Lot indication

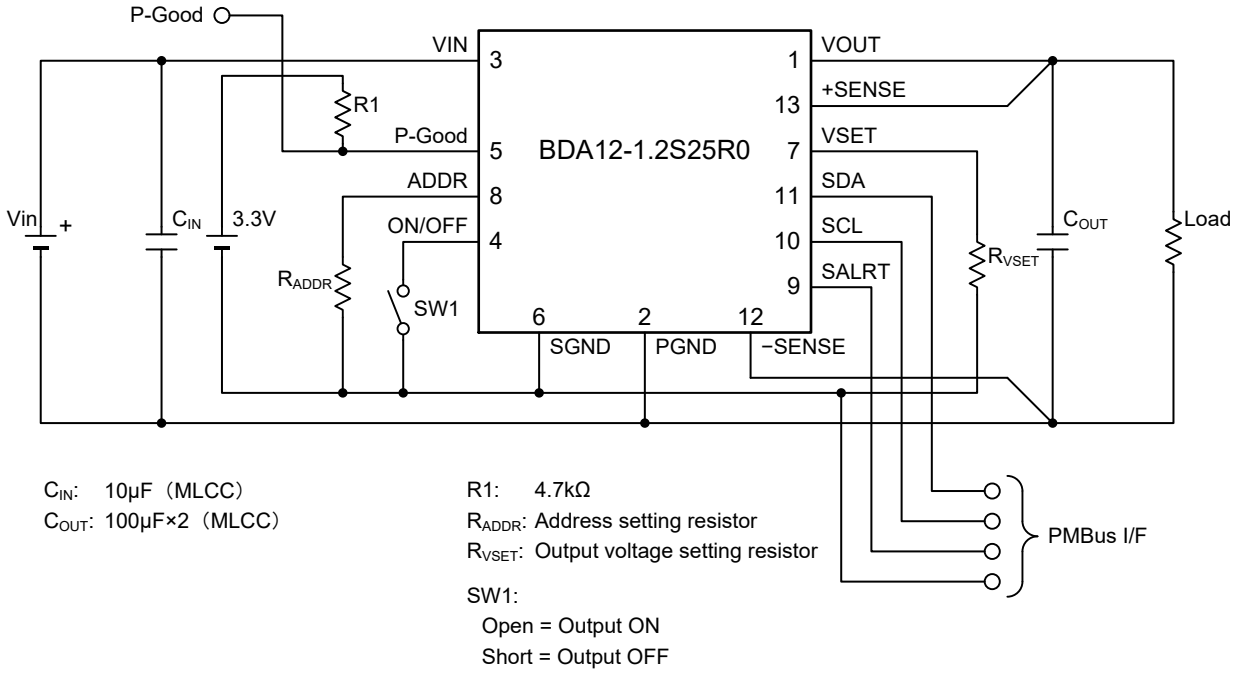
Example:

2 5 4 （Manufactured in April 2025）

2 5 N 2 （Manufactured in November 2025）

- 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 two digits of A.D.)

7. Standard connection diagram



Note 1) Be sure to connect +SENSE and −SENSE pins to the converter. The sensing lines (the lines from +SENSE and −SENSE pin to both sides of C_{OUT}) are part of the feedback loop. To prevent noise from affecting the sensing lines, avoid routing it unnecessarily long, route the wires as a pair, and provide shielding by placing SGND planes on the layers above and below.

Note 2) This product is designed to be mounted on a printed circuit board (PCB), with the assumption that heat dissipation will be achieved through the board itself. Please design the PCB with as wide a copper pattern as possible to facilitate effective heat dissipation.

Note 3) Avoid routing any traces underneath this product on the first layer of the PCB. This restriction does not apply to layers other than the top layer on the converter side.

Note 4) R_{ADDR} is a resistor set at the shipment from factory as the device address for PMBus communication. Please change the resistor value to be suited to required address.

Note 5) R_{VSET} is the output voltage setting resistor. Please connect a resistor with a value appropriate for the required output voltage. Do not leave the VSET pin open.

Note 6) Even if the PMBus communication function is not used, the SDA and SCL pins must be pulled up using resistors or an equivalent method. The SALRT pin can be left open with no problem.

Note 7) Be sure to add the input capacitor (C_{IN}) and the output capacitor (C_{OUT}). Those capacitors are required to satisfy specified characteristics. Those should be placed as close as possible to the converter pins.

Note 8) Set the wires or traces between input power source to the converter so that the line impedance should be low. If the line impedance is high, the converter input voltage may become unstable. In that case, in parallel with C_{IN}, connect a capacitor of a capacitance value that settles the unstable behavior of the input voltage.

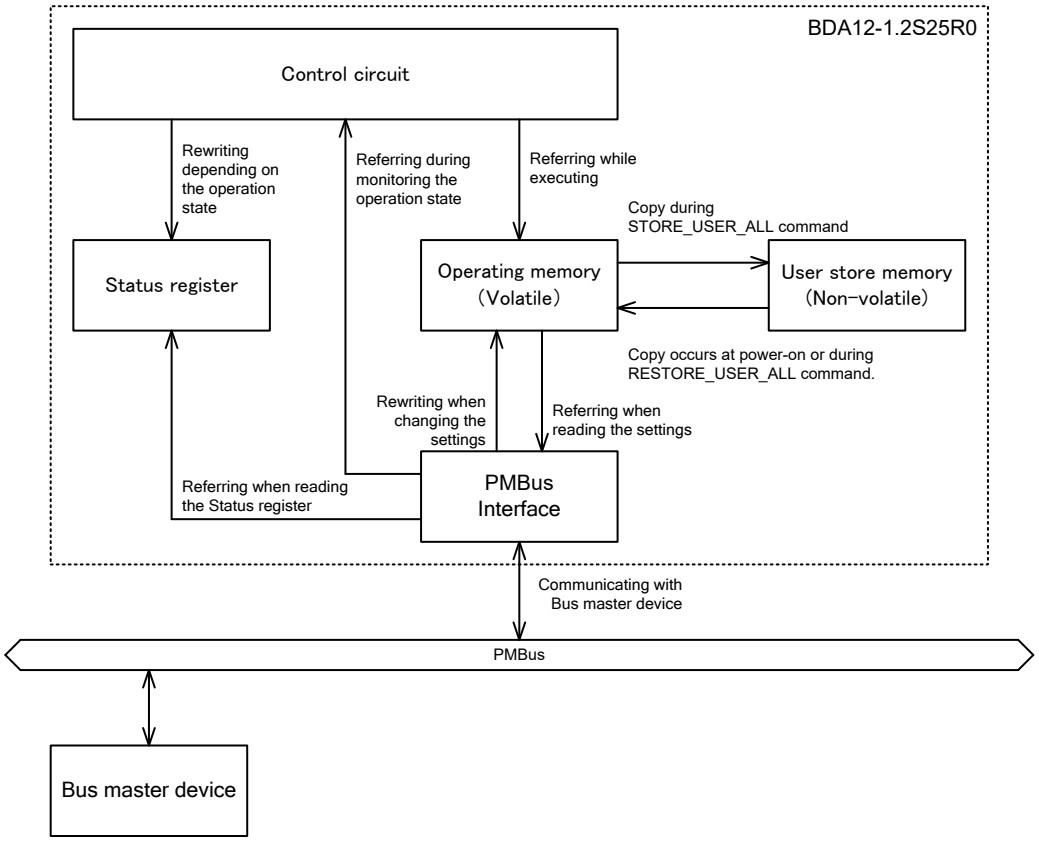
Note 9) When adding the output capacitor C_{OUT}, the converter may not start depending on the capacitance. Be sure to check in actual application circumstance.

8. Functions

8-1 Digital control

The PMBus 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 the volatile operating memory and the 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 to the operating memory during start-up.

The control circuit reads the contents of the operating memory. The contents will be re-written when the settings are changed via serial communication. As the operating memory is volatile, any changes will be lost when the power is turned off.

In order to change the setting values set at start-up, it is required to rewrite the operating memory and then save the new setting values into the non-volatile user store memory by STORE_USER_ALL command.

RESTORE_USER_ALL commands can also modify the contents of the operating memory to those stored in the user store memory (reverting to the settings at the time of the previous STORE_USER_ALL command execution).

Items	PMBus commands
Save Settings	STORE_USER_ALL
Restore Settings	RESTORE_USER_ALL

Note: Usable data storing capacity decreases in the user store memory each time settings are saved. Please limit the use of the STORE_USER_ALL command to 10 times.

8-2 Output voltage setup

The output voltage can be set in the range of 0.5 to 1.2V by connecting a resistor to the VSET pin or by using PMBus communication.

8-2-1 Output voltage setting with VSET pin

By connecting a resistor between the VSET and SGND pin, the output voltage can be set in 0.1V increments.

The correspondence between output voltage and resistance value (R_{VSET}) is as follows:

The VSET pin cannot be set to any output voltage other than that listed in the table below. The resistor tolerance should be 1% (E96 series).

The output voltage corresponds to the resistance between the VSET and SGND pins at startup.

When changing the output voltage, set the input voltage to 0V once.

Output Voltage [V]	R_{VSET} [kΩ]	Output Voltage [V]	R_{VSET} [kΩ]
0.5	5.62	0.9	30.1
0.6	9.53	1.0	36.5
0.7	14.0	1.1	51.1
0.8	21.0	1.2	61.9

Note: We cannot guarantee the operation when connecting resistors other than the values in the table above.

8-2-2 Output voltage setting via PMBus communication

PMBus communication allows the output voltage to be changed during operation.

The output voltage setting value is reset to the value corresponding to the VSET pin when the output is changed from OFF to ON by the ON/OFF control (both ON/OFF pins and PMBus communication).

When setting the output voltage using PMBus, implement it after the output voltage has been raised. If the output voltage is set during the output is OFF, the output will not be the set properly.

Item	PMBus command	Setting range	Resolution	Factory setting
Output voltage	VOUT_COMMAND	0.5 to 1.2V	Approx. 0.244mV (2^{-12}V)	Responds to VSET pin

Note: The resolution of the actual output voltage is limited by the internal DAC. The resolution of the internal DAC is 0.625 mV.

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 controlled 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 0.5 to 1.2V via PMBus communication.

Items	PMBus commands	Setting range	Resolution	Factory settings
Output voltage in the Margin OFF State	VOUT_COMMAND	0.5 to 1.2V	Approx. 0.244mV (2^{-12}V)	Responds to VSET pin
Output voltage in the Margin High State	VOUT_MARGIN_HIGH	0.5 to 1.2V	Approx. 0.244mV (2^{-12}V)	0.5V
Output voltage in the Margin Low State	VOUT_MARGIN_LOW	0.5 to 1.2V	Approx. 0.244mV (2^{-12}V)	0.5V

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 command	Factory setting
Switching Margin States	OPERATION	Margin OFF

Note: Margin High and Margin Low voltages do not work along with the output voltage setting by the VSET pin.

8-4 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. By this function, the output voltage is set to the limit value even if it is accidentally set beyond specified voltage range. This function only limits the maximum setting value and does not provide overvoltage protection.

The output voltage limit setting is set corresponding to the output voltage setting value by R_{VSET} resistor. Limit setting will be 0.15V above output voltage setting value if it is set on 0.5 to 0.7V. And 0.2V above output voltage setting value if it is set on 0.8 to 1.2V.

Changing the output voltage setting in PMBus communication does not affect the limit of output voltage setting.

The output voltage setting limit can also be changed via PMBus communication.

The output voltage setting limit is reset to the value corresponding to the VSET pin when the output is changed from OFF to ON by the ON/OFF control (both ON/OFF pins and PMBus communication).

Item	PMBus command	Setting range	Resolution	Factory setting
Output voltage limit	VOUT_MAX	0.5 to 1.4V	Approx. 0.244mV (2^{-12}V)	Responds to VSET pin (*1)

*1 V_{OUT} = 0.5 to 0.7V: VOUT_MAX = V_{OUT} + 0.15V
V_{OUT} = 0.8 to 1.2V: VOUT_MAX = V_{OUT} + 0.20V

Note: When the output voltage is set to 1.1V or 1.2V by the VSET pin, the output voltage setting limit value is set to a value greater than 1.2V, but this does not mean that the output voltage is allowed to be set to a value greater than 1.2V.

When changing the output voltage setting value via PMBus communication, the upper limit should be 1.2V.

8-5 Remote sensing

By using this function, excellent load regulation characteristics can be obtained on the load side. The sensing lines are part of the feedback loop and are very sensitive, thus extra care must be taken when routing sensing patterns. The +SENSE and –SENSE lines should be routed close together and connected to the load. In addition, the upper and lower layers of the sensing lines should be provided with SGND solids and shielded.

When this function is not used, be sure to connect VOUT and +SENSE pins as well as the PGND and –SENSE pins.

8-6 ON/OFF control

By using the ON/OFF control function, ON/OFF of the output voltage can be controlled without applying and shutting down the input source. It can be controlled by two methods, one is to use the ON/OFF pin, and another is to use the PMBus communication. Each method can be set to “Enabled” or “Disabled” by PMBus communication. Both of those control methods are set to "Enabled" at factory shipment.

8-6-1 ON/OFF control by the ON/OFF pin

ON/OFF of VOUT can be controlled by opening or short-circuiting between the ON/OFF pin and SGND pin.

ON/OFF pin is internally connected to VIN pin through the resistance of 47kΩ ±1%.

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 via PMBus communication. It is set to positive logic at factory shipment.

For turning off by using the ON/OFF pin, either of immediately stopping switching or stopping it after a sequence is applied can be set. Which stop method to apply can be set using PMBus communication (ON_OFF_CONFIG command). It is set to stop with the sequence at factory shipment.

Between the ON/OFF pin – SGND pin	Output	Remarks
OPEN	ON (positive logic) OFF (negative logic)	ON/OFF Pin Open Voltage：VIN
SHORT (0 to 0.59V)	OFF (positive logic) ON (negative logic)	

Note: Be careful not to induce chattering between ON/OFF pin and SGND pin.

8-6-2 ON/OFF control via PMBus communication

The ON/OFF of output voltage can be controlled via PMBus communication.

For turning off via PMBus communication, either of immediately stopping switching or stopping it after a sequence is applied can be selected.

Items	PMBus commands	Factory settings
ON/OFF control via PMBus communication	OPERATION	Output ON
Operation setting of ON/OFF control *1	ON_OFF_CONFIG	ON/OFF control by ON/OFF pin: Enabled ON/OFF control via PMBus communication: Enabled Turn OFF control by ON/OFF pin with sequence: Enabled

*1 If both of the ON/OFF controls by ON/OFF pin and that via PMBus communication are enabled, the output settings are resulted in as AND logic as shown in below table.

Setting by ON/OFF pin	Settings by PMBus – OPERATION commands	Output settings
ON	ON	ON
ON	OFF	OFF
OFF	ON	OFF
OFF	OFF	OFF

8-7 Sequence setup

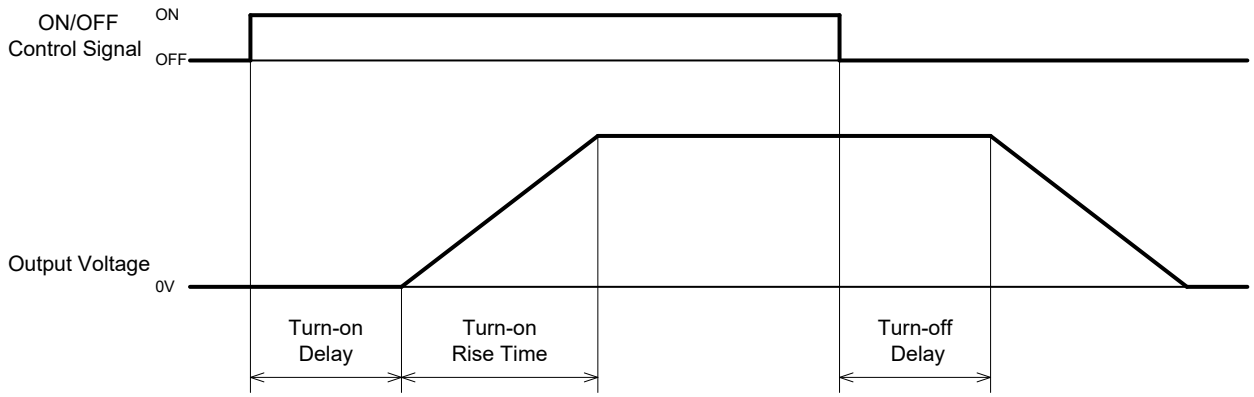
The following items can be set by using Sequence Setting function.

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

Turn-on Delay is a period from the time that the ON command is issued by the ON/OFF control (by the ON/OFF pin or PMBus communication) until output voltage start rising. (See the timing chart.)

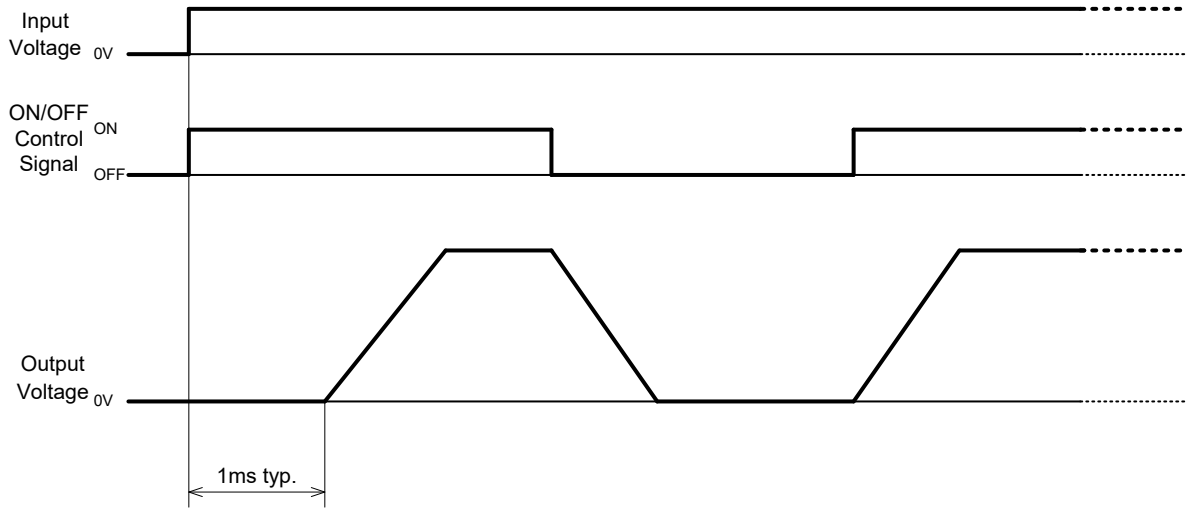
Turn-off Delay is a period from the time that the OFF command is issued until output voltage start falling. (See the timing chart.)

Note: Contact us if Turn-off Fall Time is needed to set.



When input voltage is applied, there is 1ms (typ.) delay until the voltage rising sequence works on. (See the timing chart blow.)

Each setting value for the sequence can be set via PMBus communication. However, Turn-on Rise Time may be differ from the set value depending on output capacitance, Cout.



Items	PMBus commands	Setting range	Resolution	Factory settings
Turn-on delay	TON_DELAY	0 to 127.5ms	0.5ms	0ms
Turn-on rise time	TON_RISE	0.5 to 127.5ms	0.5ms	2ms
Turn-off delay	TOFF_DELAY	0 to 127.5ms	0.5ms	0ms

Note: The turn-on delay has an additional delay of up to 0.1ms.

Turn-off delay setting does not apply when operation is stopped due to protection functions (Under voltage lock out, Input overvoltage protection, Output overvoltage protection, Overcurrent protection, Overheating protection).

8-8 Output voltage transition rate setting

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

Item	PMBus command	Setting range	Resolution	Factory setting
Output voltage transition rate	VOUT_TRANSITION_RATE	0.125 to 10mV/μs	0.125mV/μs	1mV/μs

8-9 P-Good signal output

P-Good pin allows monitoring the status of DC/DC converter output. This pin is an open drain output.

If the output voltage (+SENSE pin--SENSE pin-to-SENSE pin-to-pin voltage) exceeds the P-Good ON threshold, it is open (high impedance), and if it is below the P-Good OFF threshold, it is Low.

P-Good pin signal	Pin voltage	Remarks
OPEN	—	Allowable Applied Voltage 3.6V max.
Low	0.4V max.	Sink current 5mA max.

Note: At start up, P-Good pin may not function and be open until input voltage rises to workable voltage.

The P-Good ON and P-Good OFF thresholds are determined in conjunction with the output voltage setting set by the VSET pin, with the ON threshold being 93.75% of the output voltage setting and the OFF threshold being 81.25%.

That even if the output voltage setting is changed via PMBus communication, the P-Good ON threshold and P-Good OFF threshold will not be affected. If necessary, set it to the appropriate values.

In addition, the P-Good ON threshold and P-Good OFF threshold can be changed by PMBus communication.

The P-Good ON threshold and P-Good OFF threshold are reset to the values corresponding to the VSET pin when the output is changed from OFF to ON by the ON/OFF control (both ON/OFF pin and PMBus communication).

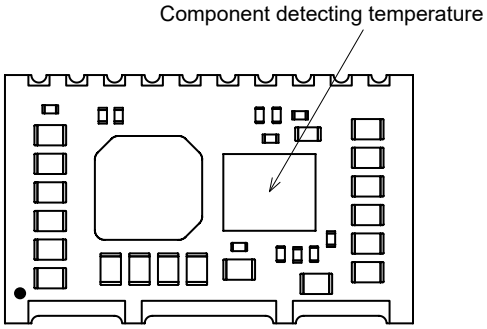
Items	PMBus commands	Setting range	Resolution	Factory settings
P-Good ON threshold	POWER_GOOD_ON	0.4 to 1.2V	Approx. 0.244mV (2^{-12}V)	VSET × 0.9375
P-Good OFF threshold	POWER_GOOD_OFF	0.4 to 1.2V	Approx. 0.244mV (2^{-12}V)	VSET × 0.8125

8-10 Operation state monitoring

Input voltage, output voltage, output current and converter temperature of the product can be obtained via PMBus communication.

Items	Monitor accuracy	Conditions
Monitoring input voltage	±2% typ.	
Monitoring output voltage	±2% typ.	
Monitoring output current	±6% typ.	10A < I_{OUT}
Monitoring Converter Temperature	±3°C typ.	

The converter temperature is detected by the component shown below.



This product contains 7 status registers, STATUS_BYTE, STATUS_WORD, STATUS_VOUT, STATUS_IOUT, STATUS_INPUT, STATUS_TEMPERATURE, STATUS_CML. 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
- Turn off the output with the ON/OFF pin
- OPERATION command to turn off the output and then turn it on
- Re-startup input

The contents of each register can be read out via serial communication.

Refer to the command list for each register in details.

Items	PMBus commands
Monitoring input voltage	READ_VIN
Monitoring output voltage	READ_VOUT
Monitoring output current	READ_IOUT
Monitoring Converter Temperature	READ_TEMPERATURE_1
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

8-11 Under Voltage Lock Out (UVLO)

This function prevents the product from malfunction when input voltage drops. When the input voltage reaches or exceeds the start voltage, the product is ready to start switching operation, and when the input voltage falls below the stop voltage, the product stops switching operation.

8-12 Input overvoltage protection

When the input voltage is 15V typ. or greater, the input overvoltage protection function works on and switching operation stops. This function is latch-type and does not automatically recover.

To release the latch state, reapply the input or turn it off once using the ON/OFF control (ON/OFF pin or PMBus communication).

Note: Do not apply any voltage exceeding 14V to the input as it is out of specified input voltage range. The operating threshold of the input overvoltage protection function is set outside the input voltage specification range. Although it is described as an input overvoltage protection function, please use this product within specified input voltage range so that the input overvoltage protection function does not work on.

8-13 Output overvoltage protection

When the output voltage (voltage between the +SENSE pin and -SENSE pin) reaches or exceeds1.5V typ., the output overvoltage protection function is activated and switching operation is stopped.

However, this function does not work if overvoltage occurs due to the damage to this product.

This function is latch-type and does not automatically recover. To release the latch state, reapply the input or turn it off once by using the ON/OFF control (ON/OFF pin or PMBus communication).

8-14 Output overcurrent protection

When output goes into an overcurrent state, switching operation is stopped and restarts turn-on sequence after 8ms (typ.). When the overcurrent state is cleared, switching operation restarts and the output voltage returns to normal.

Note: Avoid maintaining an overcurrent condition for a long time period.

8-15 Overtemperature warning

When the detected temperature of this product exceeds the threshold of the overtemperature warning function, the corresponding bit in the status register is set to notify that the overtemperature warning function has been activated. This function only notifies and does not stop switching operation.

The operating threshold of the overtemperature warning function can be set via PMBus communication.

Item	PMBus command	Setting range	Resolution	Factory setting
Overtemperature warning threshold	OT_WARN_LIMIT	0 to 125°C	1°C	120°C

For the temperature detection position of this product, please refer to section “8-10”.

8-16 Overtemperature protection

If the detected temperature of this product exceeds 140°C typ., the thermal protection function will be activated and switching operation will be stopped.

This function is latch-type and will not automatically recover. To release the latched state, either reapply the input power or turn it OFF once by using the ON/OFF control (ON/OFF pin or PMBus communication).

For the temperature detection position of this product, see section “8-10”.

9. PMBus communication

9-1 Definitions of Symbols and Terms

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

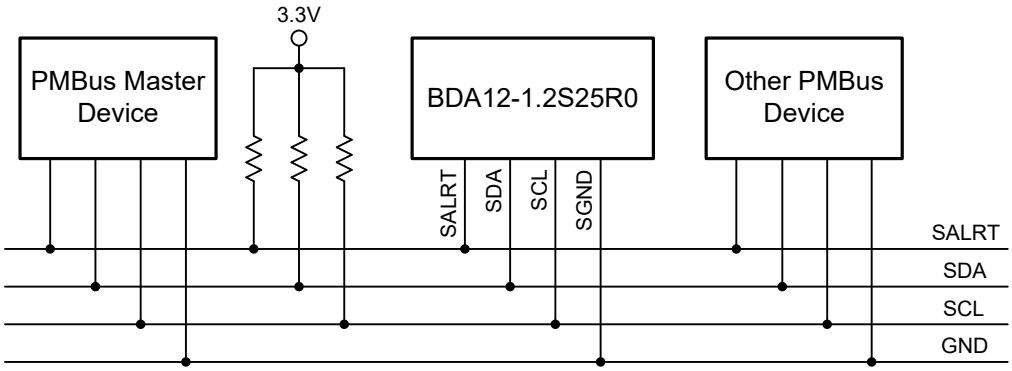
Symbols or Terms	Definition
Byte	8 bits
Word	16 bits (2 bytes)
Set	When referring to a bit or bits, this means setting the value to one.
Clear	When referring to a bit or bits, this means setting the value to zero.
nnb	Number “nn” should be in a binary value
nnh	Number “nn” should be a value in hexadecimal notation

9-2 Communication method

PMBus interface of the product complies with PMBus Specification Revision1.3.

9-3 Communication pins

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



Note: Absolute maximum ratings of PMBus communication pins (SDA, SCL, SALRT) are 3.6V max.

9-3-1 SDA pin

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

Input Low level: 0.8V max.

Input High level: 1.35V min.

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

9-3-2 SCL pin

The SCL pin is a clock input pin used for PMBus communication. The SCL pin is not driven by this product. The SCL pin should be driven by a bus master device.

Input Low level: 0.8V max.

Input High level: 1.35V min.

Input frequency: 1000 kHz max.

9-3-3 SALRT pin

The SALRT pin is an abnormal alert signal output pin that is an open drain output.

The pin is open in normal state and low in abnormal state.

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

9-4 Device address setup

In PMBus communication, device address is used to identify each device as multiple devices share a single bus. Device addresses must be set so that there are no duplicates on the same bus.

This product has two device addresses: one for PMBus communication and one for factory settings.

The device address is set by connecting a resistor between the ADDR and SGND pins. The correspondence between the resistor value (R_{ADDR}) and the device address is as follows. Use a resistor of 1% tolerance (E96 series).

The device address is determined by the resistance value between ADDR and SGND pins when the input power is applied. When changing the device address, set the input voltage to 0V once.

If the communication function is not used, there is no problem even if ADDR pin is left open.

R_{ADDR} [kΩ]	Device address (PMBus)	Device address (for factory settings)
0	1010 000	0010 000
5.62	1010 001	0010 001
9.53	1010 010	0010 010
14.0	1010 011	0010 011
21.0	1010 100	0010 100
30.1	1010 101	0010 101
36.5	1010 110	0010 110
43.2	1010 111	0010 111
51.1	1011 000	0011 000
61.9	1011 001	0011 001
75.0	1011 010	0011 010
88.7	1011 011	0011 011
105	1011 100	0011 100
127	1011 101	0011 101
147	1011 110	0011 110
Float	1011 111	0011 111

Note: Do not access the address for the converter factory settings.

9-5 Data format

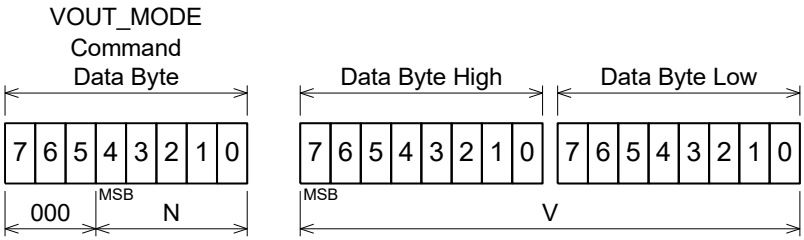
9-5-1 16-Bit Linear Format

It is a data format used to represent values related to output voltage and consists of the following elements:

N; 5bit Exponent (two's complement signed binary integer),

V; 16bit Mantissa (unsigned binary integer).

The 5bit exponent *N* can be read by VOUT_MODE command. *N* is set to −12.



The relationship between the values of Voltage expressed by the Linear Format and the exponent N and the mantissa V is as follows.

Voltage $= V \times 2^N$

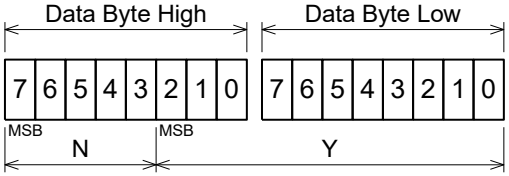
9-5-2 11-Bit Linear Data Format

It is a two-byte value that is used to express other than value related to the output voltage such as current, time or temperature.

It is a two-byte value that is used to express values other than the output voltage, consisting of:

N; 5bit Exponent (two's complement signed binary integer),

Y; 11bit Mantissa (two's complement signed binary integer).



The relationship between the value X expressed by the Linear Data Format and the exponential part N and mantissa Y is as follows.

$X = Y \times 2^N$

9-6 PMBus commands

9-6-1 PMBus command list

The following PMBus commands can be used for this product.

PMBus commands	Command code	Transaction type ∗1	Number of Data Bytes	Data Format	Unit	Factory settings
OPERATION	01h	R/W Byte	1	—	—	80h
ON_OFF_CONFIG	02h	R/W Byte	1	—	—	1Eh
CLEAR_FAULTS	03h	Send Byte	0	—	—	—
STORE_USER_ALL	15h	Send Byte	0	—	—	—
RESTORE_USER_ALL	16h	Send Byte	0	—	—	—

VOUT_MODE	20h	Read Byte	1	—	—	Linear *N* = −12
VOUT_COMMAND	21h	R/W Word	2	16-Bit Linear	V	Respond to VSET
VOUT_MAX	24h	R/W Word	2	16-Bit Linear	V	Respond to VSET
VOUT_MARGIN_HIGH	25h	R/W Word	2	16-Bit Linear	V	0800h (0.5V)
VOUT_MARGIN_LOW	26h	R/W Word	2	16-Bit Linear	V	0800h (0.5V)
VOUT_TRANSITION_RATE	27h	R/W Word	2	11-Bit Linear	mV/μs	E808h (1mV/μs)
OT_WARN_LIMIT	51h	R/W Word	2	11-Bit Linear	°C	0078h (120°C)
POWER_GOOD_ON	5Eh	R/W Word	2	16-Bit Linear	V	Respond to VSET
POWER_GOOD_OFF	5Fh	R/W Word	2	16-Bit Linear	V	Respond to VSET
TON_DELAY	60h	R/W Word	2	11-Bit Linear	ms	F800h (0ms)
TON_RISE	61h	R/W Word	2	11-Bit Linear	ms	F804h (2ms)
TOFF_DELAY	64h	R/W Word	2	11-Bit Linear	ms	F800h (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	—	—	—
READ_VIN	88h	Read Word	2	11-Bit Linear	V	—
READ_VOUT	8Bh	Read Word	2	16-Bit Linear	V	—
READ_IOUT	8Ch	Read Word	2	11-Bit Linear	A	—
READ_TEMPERATURE_1	8Dh	Read Word	2	11-Bit Linear	°C	—

*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
R/W Byte	Read Byte Protocol and Write Byte Protocol
R/W Word	Read Word Protocol and Write Word Protocol

9-6-2 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				Output ON/OFF	Output voltage settings (Margin State)	Output Turn-off behavior	Factory setting
7–6	5–4	3–2	1–0				
00	00	00	00	OFF	—	There is no turn-off sequence. Output is turned off immediately.	
01	00	00	00	OFF	—	There is turn-off sequence. Device stops along with the sequence set by TOFF_DELAY command.	
10	00	00	00	ON	VOUT_COMMAND (Margin OFF)	—	●
10	01	01 or 10	00	ON	VOUT_MARGIN_LOW (Margin Low)	—	
10	10	01 or 10	00	ON	VOUT_MARGIN_HIGH (Margin High)	—	

Note: The behavior when any setting values for combinations not listed above is undefined.

If the ON/OFF control is disabled via PMBus communication using the ON_OFF_CONFIG command, the ON/OFF function cannot be controlled by this command.

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	Purpose	Value	Description	Factory settings
7–5	—	000	Reserved	
4	To Select enable or disable of the ON/OFF control	0	Disable ON/OFF control by ON/OFF pin and PMBus communication (always set to ON)	
		1	Enable ON/OFF control by ON/OFF pin and PMBus communication	●
3	To select enable or disable of the ON/OFF control via PMBus communication	0	Disable ON/OFF Control via PMBus communication	
		1	Enable ON/OFF Control via PMBus communication	●
2	To select enable or disable of the 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	Logic of the ON/OFF pin	0	Negative (Output is ON when SHORT)	
		1	Positive (Output is ON when OPEN)	●
0	Select enable or disable the turn-off sequence when turned off by using the ON/OFF pin.	0	Device powers down following the values set in the TOFF_DELAY command.	●
		1	Output is turned off immediately.	

Note: When ON/OFF control by ON/OFF pin and PMBus communication are enabled, AND operation is performed. (see section 8-6-2).

9-6-4 CLEAR_FAULTS command (03h)

This is a command to clear all the bits in a status register.

As this command is used only to clear all the bits in status registers, if this command is executed without eliminating the cause of the status register being set, the status register will be set again.

9-6-5 STORE_USER_ALL command (15h)

Store the contents of operating memory to the non-volatile user store memory.

Note: After executing this command, be sure to maintain the input voltage for 0.2 seconds. Otherwise, the contents of the user store memory can be corrupted and unrecoverable.

9-6-6 RESTORE_USER_ALL command (16h)

Change the contents of operating memory to the contents stored in non-volatile user store memory.

9-6-7 VOUT_MODE command (20h)

This command is used to read data formats for output voltage related commands.

This product is only compatible with Linear Mode.

The data byte is one byte. The bottom 5 bits are the 5-bit signed integers, which represent the exponential part of the Linear Format.

It returns 14h (Linear Mode, exponent N = −12).

9-6-8 VOUT_COMMAND command (21h)

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

9-6-9 VOUT_MAX command (24h)

This command is used to set the output voltage limit value.

9-6-10 VOUT_MARGIN_HIGH command (25h)

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

9-6-11 VOUT_MARGIN_LOW command (26h)

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

9-6-12 VOUT_TRANSITION_RATE command (27h)

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

9-6-13 OT_WARN_LIMIT command (51h)

This command is used to set the overtemperature warning threshold.

9-6-14 POWER_GOOD_ON command (5Eh)

This command is used to set the P-Good ON threshold.

9-6-15 POWER_GOOD_OFF command (5Fh)

This command is used to set the P-Good OFF threshold.

9-6-16 TON_DELAY command (60h)

This command is used to set the Turn-on delay.

9-6-17 TON_RISE command (61h)

This command is used to set the Turn-on rise time.

9-6-18 TOFF_DELAY command (64h)

This command is used to set the Turn-off delay.

9-6-19 STATUS_BYTE command (78h)

This command is used to read the STATUS_BYTE register.

Meanings of each bit are described below.

Bit	Bit name	Description
7	—	Unused
6	OFF	1 when output is OFF (OFF by protection functions as well as the ON/OFF control).
5	VOUT_OV_FAULT	1 when the output overvoltage protection is activated.
4	IOUT_OC_FAULT	1 when the output overcurrent protection is activated.
3	—	Unused
2	TEMPERATURE	1 when any bit of STATUS_TEMPERATURE register is set to 1.
1	CML	1 when any bit of STATUS_CML register is set to 1.
0	NONE_OF_THE_ ABOVE	1 when a protection or warning function not listed in bits [7:1] of this byte (*1) is activated.

*1 P-Good signal (bit 11 of STATUS_WORD) is also included.

9-6-20 STATUS_WORD command (79h)

This command is used to read the STATUS_WORD register.

Meanings of each bit are described below.

Bit	Bit name	Description
15	VOUT	1 when any bit of STATUS_VOUT register is set to 1.
14	IOUT	1 when any bit of STATUS_IOUT register is set to 1.
13	INPUT	1 when any bit of STATUS_INPUT register is set to 1.
12	—	Unused
11	POWER_GOOD#	Negative logic P-Good signal. 1 in condition that P-Good pin becomes low.
10	—	Unused
9	—	Unused
8	—	Unused
7	—	unused
6	OFF	1 when output is OFF (OFF by protection features as well as the ON/OFF control.)
5	VOUT_OV_FAULT	1 when the output overvoltage protection is activated.
4	IOUT_OC_FAULT	1 when the output overcurrent protection is activated.
3	—	Unused
2	TEMPERATURE	1 when any bit of STATUS_TEMPERATURE register is set to 1.
1	CML	1 when any bit of STATUS_CML register is set to 1.
0	NONE_OF_THE_ ABOVE	1 when a protection or warning function not listed in bits [7:1] of this byte (*1) is activated.

*1 P-Good signal (bit 11 of STATUS_WORD) is also included.

9-6-21 STATUS_VOUT command (7Ah)

This command is used to read the STATUS_VOUT register.

Meanings of each bit are described below.

Bit	Description
7	1 when output overvoltage protection is activated
6–4	Unused
3	1 when maximum limit of output voltage is activated
2–0	Unused

9-6-22 STATUS_IOUT command (7Bh)

This command is used to read the STATUS_IOUT register.

Meanings of each bit are described below.

Bit	Description
7	1 when output overcurrent protection is activated
6–0	Unused

9-6-23 STATUS_INPUT command (7Ch)

This command is used to read the STATUS_INPUT register.

Meanings of each bit are described below.

Bit	Description
7	1 when input overvoltage protection is activated
6–4	Unused
3	1 when under voltage lock out is activated
2–0	Unused

9-6-24 STATUS_TEMPERATURE command (7Dh)

This command is used to read STATUS_TEMPERATURE register.

Meanings of each bit are described below.

Bit	Description
7	1 when overtemperature protection is activated.
6	1 when overtemperature warning is activated.
5–0	Unused

9-6-25 STATUS_CML command (7Eh)

This command is used to read STATUS_CML register.

Contact us for the meaning of each bit.

9-6-26 READ_VIN command (88h)

This command is used to read input voltage.

9-6-27 READ_VOUT command (8Bh)

This command is used to read output voltage.

9-6-28 READ_IOUT command (8Ch)

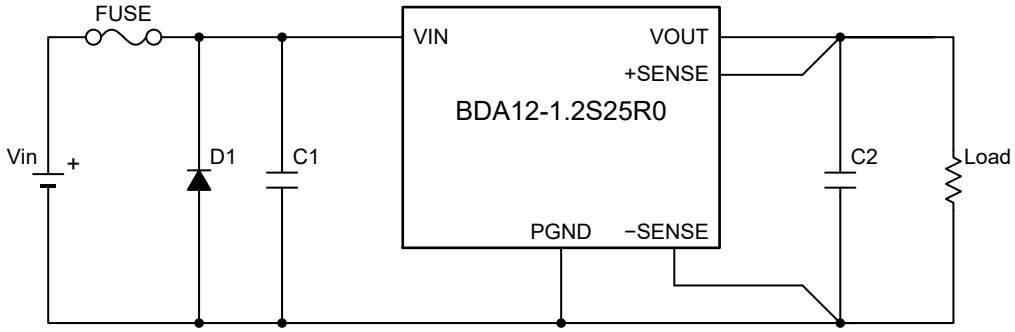
This command is used to read output current.

9-6-29 READ_TEMPERATURE_1 command (8Dh)

This command is used to read the monitored converter temperature.

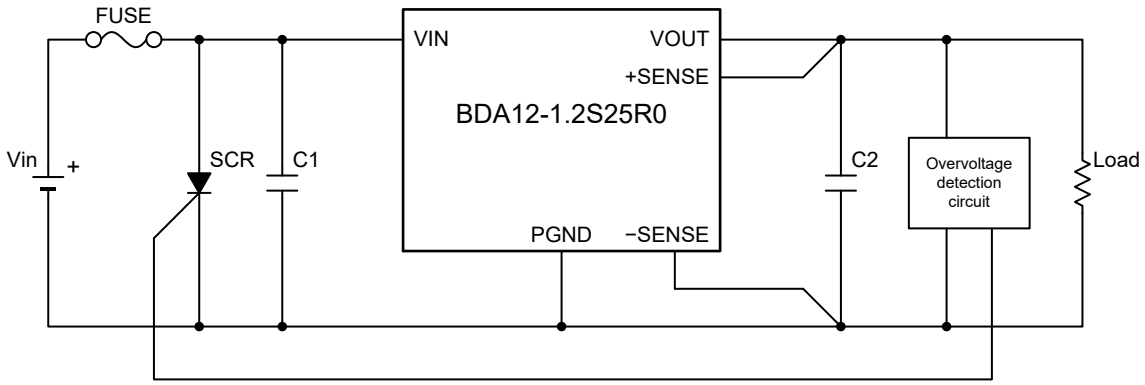
10. Protection for reverse of input (Example)

This product will be damaged if the polarity of the power supply is connected incorrectly.
If there is a risk of reverse connection, add a protection as shown in the schematic below.
The schematic below shows an example using a fuse and a diode.



11. Overvoltage protection (Example)

The product has a built-in overvoltage protection function. However, if switching device inside is damaged in short circuit mode, the DC input voltage will appear to the output. Therefore, add an input shut-off circuit as shown in the schematic below to avoid damage in overvoltage mode.



Note 1: If overvoltage is caused by damage of this product, the ON/OFF control also does not work.
Note 2: If there is an ON/OFF feature at power source side, it can be used.
Note 3: The DC power source should have a capacity that can blow the fuse.

12. Soldering conditions

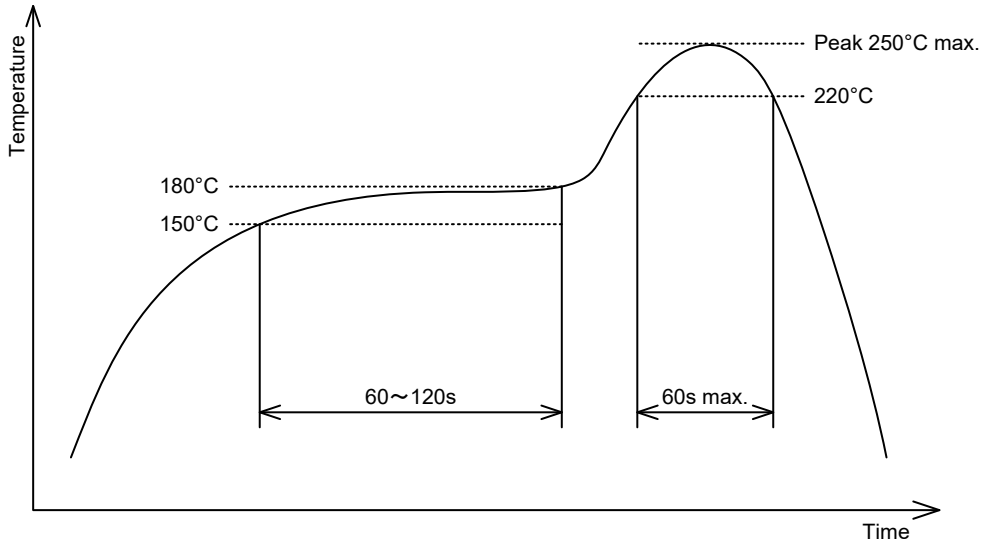
Soldering temperature/duration and the storage before soldering should be along the following conditions.

Re-flow soldering profile

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

Refrain from giving vibrations during reflow, for it may cause converter components to move.

Flow mounting is not allowed for the product.



12-1 Storage before mounting

Humidity control level for the product is JEDEC MSL3.

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

If stored in dry pack for more than one year, or if stored in opened dry pack at 30°C/60% R.H. for more than 168 hours, baking (125°C ±5°C, 12 hours) is required before reflow.

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

13. Vibration and Shock Test

Vibration: 5 to 10Hz, 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 duration 11 ±5ms

14. Cleaning

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

15. 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 to us for any use other than for such general electronics equipment.
- This product may undergo minor changes or component changes that do not significantly affect specifications without prior notice due to characteristics improvement or other reasons.
- The product is not suitable for either series or parallel operation.
- Do not use connectors and sockets for mounting this product. Contact resistance may cause performance to be unsatisfactory. Please solder this product onto the printed circuit board.
- This product has a built-in overcurrent protection circuit but avoid a prolonged short circuit state which may lead to failure.
- This product may be damaged if used out of specified electrical conditions or environmental conditions such as temperature. Ensure the use in the specified condition range.
- Avoid the storage and the use of this product in locations where corrosive gases may be generated or where it may be affected by dust.
- This product may be damaged by static electricity. Work in an environment with static electricity preventions, such as grounding and discharging static electricity from charged workers.
- No fuse is built in this product. Taking into account unexpected situation, connect a fuse to the positive input line to protect against excessive current flowing into the input. Ensure that the power source has sufficient capacity to cut off the fuse.
- This product has a built-in overvoltage protection function, however, if overvoltage occurs due to a malfunction within the module, there is a mode in which the input voltage comes out as it is at the output, which may cause smoke or fire. Be sure to add an overvoltage protection circuit to prevent it.
- No test report is attached to this product.

16. Warranty

The warranty term of the product is one year after shipment. During the warranty period, if any defects occur due to our design or manufacturing, we will repair or replace the product free of charge.

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.

17. Patent information

This product is covered by license to at least U.S. Patents: U.S. Pat. Nos.: US8086874; US7882372; US7836322; US7782029; US7743266; US7737961; US7673157; US7646382; US7583487; US7565559; US7554778; US7526660; US7493504; US7459892; US7456617; US7394445; US7373527; US7372682; US7315156; US7266709; US7249267; US7080265; US7068021; US7049798; US7000125; US6949916; US6936999; US6788036; US6741099.