ARTESYN BDQ1300-48S12B-4LI

1300 Watts Quarter-brick Converter

PRODUCT DESCRIPTION

Advanced Energy's Artesyn BDQ1300-48S12B-4LI-4 is a new generation single output digital control DC/DC converter with standard quarter-brick outline and pin configuration, as well as base plate and PMBus™ option. It delivers up to 1300W with 9.2-12.15V output voltage. Ultra high efficiency of 97.5% and excellent thermal performance makes it an ideal choice. For 48V to 12V down conversion in high power computing and storage applications. It can produce full power over an operating temperature range of -40 °C ~ +85 °C with forced air cooling. A PMBus™ interface is also provided for flexible digital control and monitoring.

TECHNICAL REFERENCE NOTE

Total Power:

1300 Watts

Input Voltage:

40 to 60 Vdc

# of Outputs:

Single

RoHS

SPECIAL FEATURES

- Delivers up to 1300W
- Ultra-high efficiency 97%
- Startup Pre-bias
- Input range: 40V - 60V
- PMBus™ function
- Excellent thermal performance
- No minimum load requirement
- Fixed switching frequency
- Base-plate for contact cooling or heatsink mounting
- ROHS 3.0 (2011/65/EU) compliant
- Remote control function (negative logic)
- Input under voltage lockout
- Input over voltage lockout
- Output over current protection
- Output over voltage protection
- Over temperature protection
- Pin length option: 4.6mm

SAFETY

- IEC/EN/UL/CSA 62368-1
- CE
- UL/TUV
- UL94,V-0

TYPICAL APPLICATIONS

- Telecom
- Datacom
- Computing and Storage

Model Numbers

Standard	Output Voltage	Structure	Pin Type	RoHS Status	PMBus™
BDQ1300-48S12B-4LI	12.15Vdc	Baseplate	Through hole	ROHS3.0 (2011/65/EU)	Yes
BDQ1300-48S12B-4L	12.15Vdc	Baseplate	Through hole	ROHS3.0 (2011/65/EU)	No

Order Information

BDQ1300	-	48	S	12	B	-	4	L	I	-	4
①		②	③	④	⑤		⑥	⑦	⑧		⑨

①	Model series	BDQ: high efficiency digital control quarter brick series. 1300: output power 1300W
②	Input voltage	48: 40V ~ 60V input range, rated input voltage 54V
③	Output number	S: single output
④	Rated output voltage	12: 12.15V output
⑤	Baseplate status	B: with baseplate
⑥	Pin length	-4: 4.6mm
⑦	RoHS status	Y: RoHS, R5; L: RoHS, ROHS3.0 (2011/65/EU)
⑧	PMBusTM interface	I: available
⑨	Revision	1. OVP OCP new fault management

Options

None

Electrical Specifications

Absolute Maximum Ratings

Stress in excess of those listed in the "Absolute Maximum Ratings" may cause permanent damage to the power supply. These are stress ratings only and functional operation of the unit is not implied at these or any other conditions above those given in the operational sections of this TRN. Exposure to any absolute maximum rated condition for extended periods may adversely affect the power supply's reliability.

Table 1. Absolute Maximum Ratings

Parameter	Model	Symbol	Min	Typ	Max	Unit
Input Voltage						
Operating -Continuous	All models	$V_{IN,DC}$	-	-	60	Vdc
Non-operating -100mS	All models		-	-	80	Vdc
Maximum Output Power	All models	$P_{O,max}$	-	-	1300	W
Isolation Voltage[1]						
Input to output	All models		-	-	800	Vdc
Input to Baseplate	All models		-	-	800	Vdc
Ambient Operating Temperature	All models	T_A	-40	-	+85	^{O}C
Storage Temperature	All models	T_{STG}	-55	-	+125	^{O}C
Voltage at remote ON/OFF pin	All models			-	15	Vdc
Logic pin voltage (to SIG_GND or Vo-), such as ADDR , CLK, DATA, SMBALERT.	All models		-0.3	-	3.6	V
Humidity (non-condensing)						
Operating	All models		-	-	95	%
Non-operating	All models		-	-	95	%

Note 1 - 1mA for 60s, slew rate of 1500V/10s. Functional insulation, pollution degree 2, input-metal part

Electrical Specifications

Input Specifications

Table 2. Input Specifications (Tested with the application circuit as Figure 15)

Parameter	Conditions[1]	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC	All	$V_{IN,DC}$	40	54	60	Vdc
Turn-on Voltage Threshold	All	$V_{IN,ON}$	35	-	40	Vdc
Turn-off Voltage Threshold	All	$V_{IN,OFF}$	34	-	39	Vdc
Input Under-voltage Lockout Hysteresis	All		1	-	3.5	Vdc
Input Over Voltage Protection	All		61	-	68	Vdc
Input Over Voltage Protection recovery voltage	All		60	-	66	Vdc
Input Over-voltage Lockout Hysteresis	All		1	-	3	Vdc
Maximum Input Current ($I_O = I_{O,max}$)	$V_{IN,DC}$ = 40Vdc	$I_{IN,MAX}$	-	-	38	A
No Load Input Current	All		-	0.14	-	A
Standby Input current	Remote OFF		-	0.03	-	A
Recommended Input Fuse	Fast blow external fuse recommended		-	-	125	A
Input Filter Component Values (C\L)	Internal values		-	0.15\28.2	-	uF\uH
Recommended External Input Capacitance	Low ESR capacitor recommended	C_{IN}	220	-	-	uF
Input Reflected Ripple Current(RMS)[2]	Through 12uH inductor		-	100	-	mA
Operating Efficiency	Ta = 25 °C Airflow = 1000LFM with 0.6"heatsink V_{IN} =54V $I_O = 100I_{O,max}$ $I_O = 50\%I_{O,max}$	η	- -	97.1 97.5	- -	% %

Note 1 - TA = 25 °C, Vin = 53Vdc, nominal Vout unless otherwise noted.
Note 2 - Input Reflected Ripple Current(RMS), Tested with the circuit as Figure 16

Electrical Specifications

Output Specifications

Table 3. Output Specifications (Tested with the application circuit as Figure 15)

Parameter		Conditions[1]	Symbol	Min	Typ	Max	Unit
Factory Set Voltage		$V_{IN,DC}$ = 53Vdc I_O= 50% $I_{O,max}$	V_O	12.05	12.15	12.25	Vdc
Total Regulation		Over set point, line, load, temperature & life	V_O	8.85	-	12.55	Vdc
Output Voltage Line Regulation		$V_{IN,DC}$ ≥ 53Vdc		-	60	120	mV
Output Voltage Load Regulation		$V_{IN,DC}$ ≥ 53Vdc		-	60	120	mV
Output Voltage Temperature Regulation		All		-	-	0.02	%/°C
Output Ripple, pk-pk[2]		20MHz bandwidth	V_O	-	200	-	mV_{PK-PK}
Output Current[3]		$V_{IN,DC}$ = 53V- 60Vdc	I_O	0	-	107	A
		40V ≤ $V_{IN,DC}$ < 53Vdc	I_O	0	-	1300/Vo	A
Output DC current-limit inception[4]		$V_{IN,DC}$ = 53V - 60Vdc		113	-	160	A
		40V ≤ $V_{IN,DC}$ < 53Vdc		1360/Vo		1800/Vo	A
V_O Load Capacitance		All	C_O	590	-	6000	uF
V_O Dynamic Response	Peak Deviation Settling Time	50%~75%~50% slew rate = 0.1A/us	$\pm V_O$ T_s	- -	250 300	- -	mV uS
Turn-on transient	Rise time	I_O = $I_{O,max}$		-	-	150	mS
	Turn-on delay	By DC input		-	-	200	mS
	Turn-on delay	By Enable		-	-	50	mS
	Turn-On overshoot	All		-	-	600	mV
	Turn-Off Undershoot	All		-	-	600	mV
Switching frequency		All	f_{SW}	-	130	-	KHz
Remote ON/OFF control (Negative (default); Positive available)	Off-state voltage	All		2.4	-	15	V
	On-state voltage	All		-0.3	-	0.8	V

Note 1 - TA=25 °C, Vin=53Vdc, nominal Vout unless otherwise noted.
Note 2 - Tested with the circuit of Figure 16.
Note 3 - Rated current for 40V ≤ Vin ≤ 60V is dependent on Vo vs Vin characteristic. See Figure 1 on following page.
Note 4 - Hiccup: auto-restart when over current condition is removed.

Electrical Specifications

Output Specifications

Table 3. Output Specifications Con't						
Parameter	**Conditions**	**Symbol**	**Min**	**Typ**	**Max**	**Unit**
Output over-voltage protection[5]	All	V_O	13	-	18	V
Output over-temperature protection[6]	Baseplate	T	95	-	130	^{O}C
Over-temperature hysteresis	All		-	-	-	^{O}C
Pre-bias	Rating Vo@0A at 53V $V_{IN,DC}$, and the max pre-bias voltage shouldn't exceed 8V	Vo	0	-	8	V

Note 5 - Hiccup: auto-restart when over voltage condition is removed.
Note 6 - Auto recovery. See Figure 13 test point A.

Electrical Specifications

BDQ1300-48S12B-4L Performance Curves

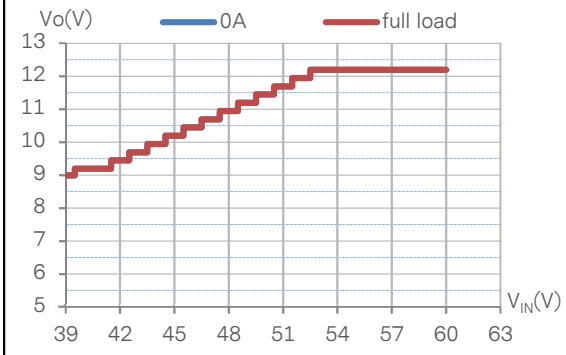


Figure 1: Output Characteristic V_O vs V_{IN}

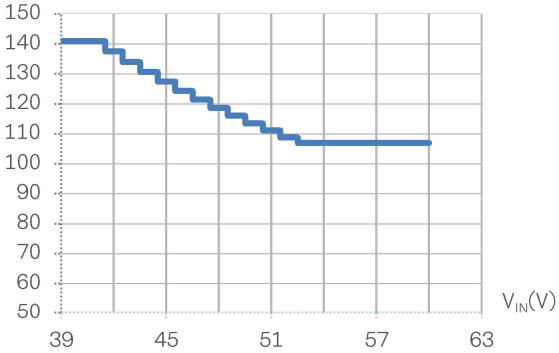


Figure 2: Output Characteristic I_o vs V_{IN}

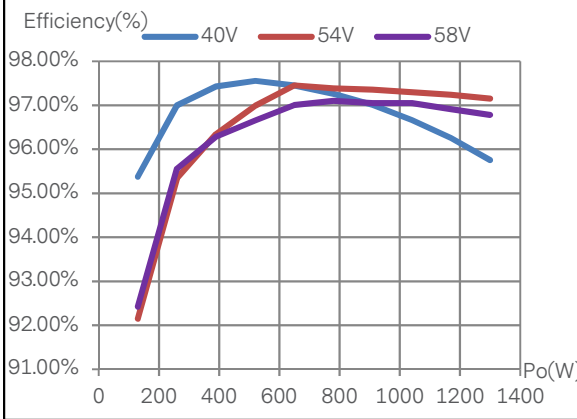


Figure 3: Efficiency vs Output Power
T_A=25°C, VIN=40V,VIN=54V, VIN=58V

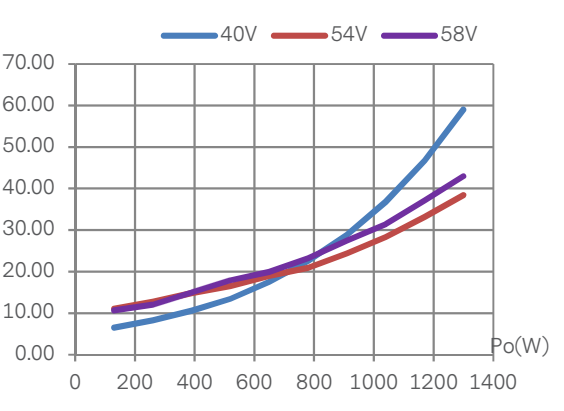


Figure 4: Power Loss vs Output Power
T_A=25°C, V_{IN}=40V,V_{IN}=54V

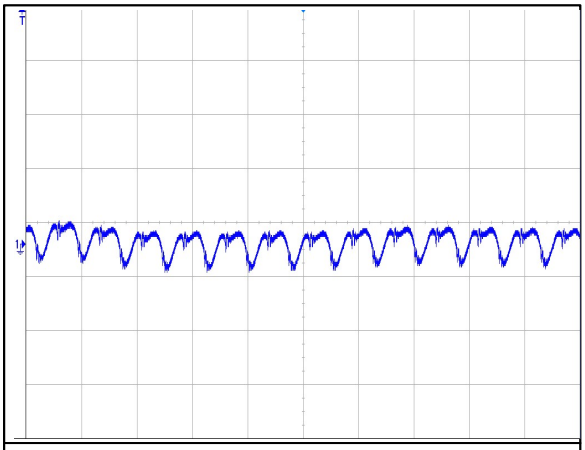


Figure 5: BDQ1300-48S12B-4L Input reflected Ripple Current Waveform
Ch1 : I_{IN} (10uS/div, 500mA/div) V_{IN}=54V, I_O=107A

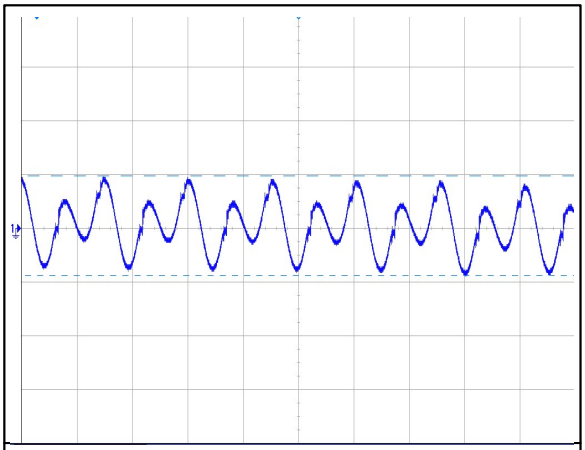


Figure 6: BDQ1300-48S12B-4L Ripple and Noise Measurement
Ch1 : V_O (5uS/div, 50mV/div) V_{IN}=54V, I_O=107A

Electrical Specifications

BDQ1300-48S12B-4L Performance Curves

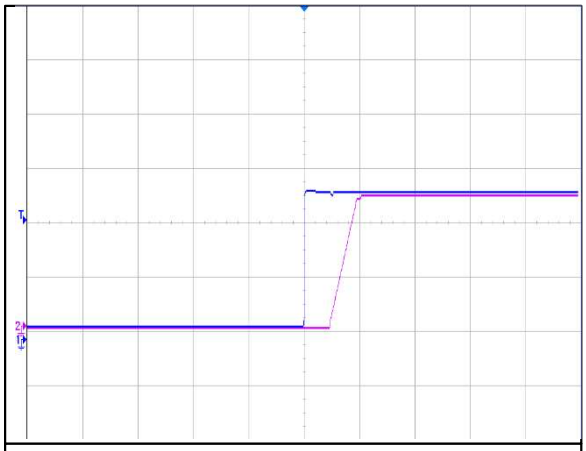


Figure 7: BDQ1300-48S12B-4L Output voltage startup by power on (50mS/div) VI_N=54V, I_O=107A
Ch 1: VI_N (20V/div) Ch 2: V_O (5V/div)

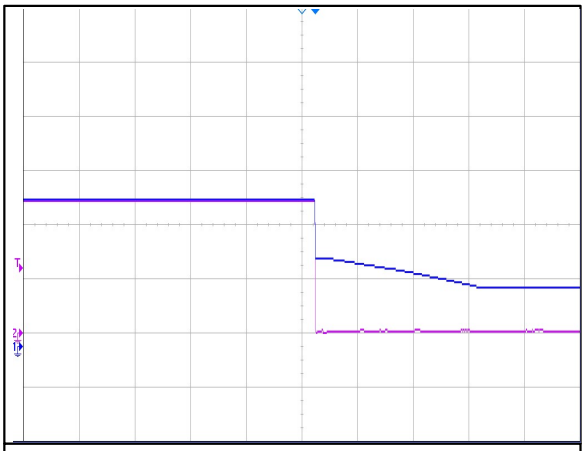


Figure 8: BDQ1300-48S12B-4L Output voltage shut down by power Off (50mS/div) V_{IN}=54V, I_O=107A
Ch 1: V_{IN} (20V/div) Ch 2: V_O (5V/div)

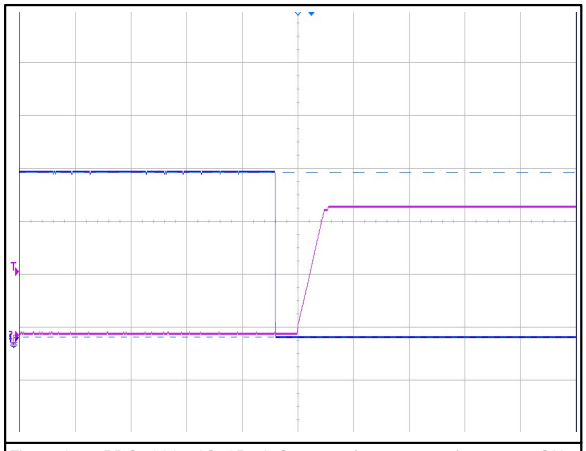


Figure 9: BDQ1300-48S12B-4L Output voltage startup by remote ON (50mS/div) V_{IN}=54V, I_O=107A
Ch 1: Remote ON (1V/div) Ch 2: V_O (5V/div)

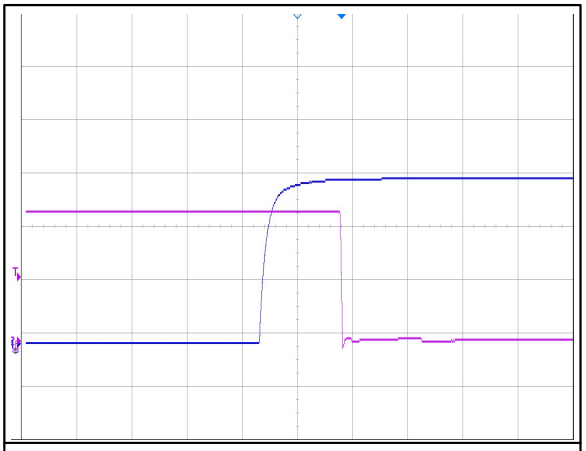


Figure 10: BDQ1300-48S12B-4L Output voltage shutdown by remote OFF (5mS/div) V_{IN}=54V, I_O=107A
Ch 1: Remote OFF (1V/div) CH2: V_O (5V/div)

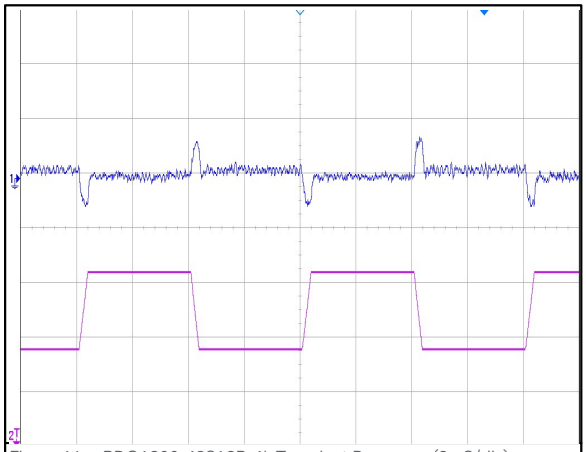


Figure 11: BDQ1300-48S12B-4L Transient Response (2mS/div) 25% load step(50%~75%~50%), 0.1A/μs slew rate V_{IN}=54V
Ch 1: V_O (500mV/div) Ch 2: I_O (20A/div)

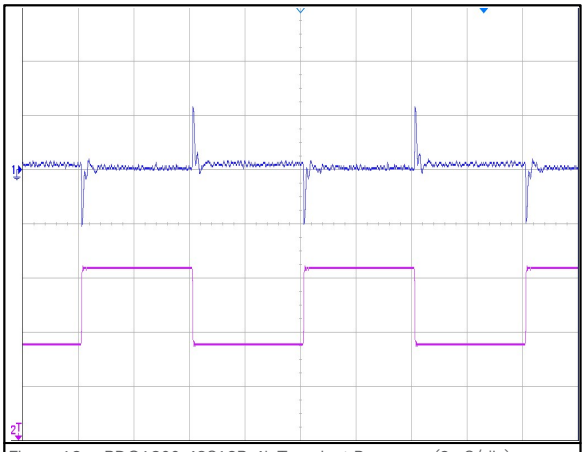


Figure 12: BDQ1300-48S12B-4L Transient Response (2mS/div) 50% load step(50%~75%~50%) , 1A/μs slew rate VI_N=54V
Ch 1: V_O (200mV/div) Ch 2:I_O (20A/div))

Electrical Specifications

PMBus™ Signal Interface Characteristics

Table 4. PMBus™ signal interface characteristics

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Input high voltage(CLK,DATA)			2.1	-	3.6	V
Input low voltage(CLK,DATA)			0	-	0.8	V
Input high level current (CLK,DATA)			-10	-	10	uA
Output low voltage (SMBALERT ,CLK,DATA)	I_O = 2mA		-	-	0.4	V
Output high level open drain leakage current (SMBALERT, DATA)	V_O = 3.6V		0	-	10	uA
PMBus operation frequency			100 / 400			KHz

Measurement System Characteristics

Table 5. Measurement system characteristics

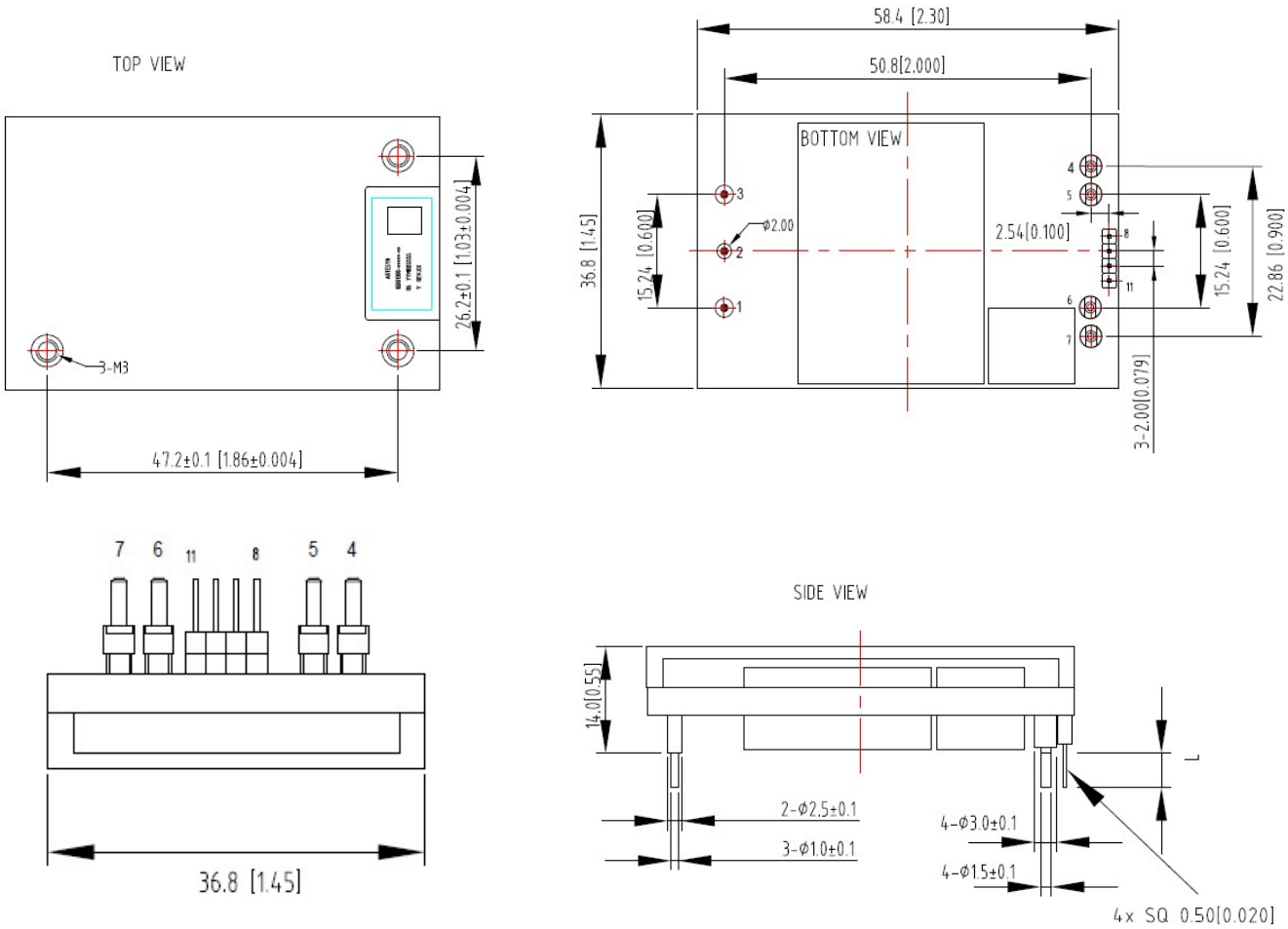
Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Output current reading accuracy*	30%< I_O <100%		-7	-	7	%
	0%< I_O ≤30%		-5	-	5	A
Output current reading resolution*			-	0.25	-	A
Vo reading accuracy			-2	1	2	%
Vo reading resolution			-	0.25	-	V
Vin reading accuracy			-4	-	4	%
Vin reading resolution			-	0.125	-	V
Input current reading accuracy*	50%<I_{IN}<100%		-10	-	10	%
	0%<I_{IN}≤50%		-1.5	-	1.5	A
Temperature reading accuracy	temperature above zero		-5	-	5	°C
Temperature reading resolution	temperature above zero		-	1	-	°C

Note: SMBALERT protocol is also supported by the module. SMBALERT is a wired-AND signal just as the CLOCK and DATA signals are, by which the module can alert the PMBus™ master that it has a fault condition via pulling the SMBALERT pin to an active low.

* Current reading accuracy and resolution at typical Vo,nom when the temperature above zero.

Mechanical Specifications

Mechanical Outlines – Baseplate Module



UNIT: mm (inch) L=4.60mm

TOLERANCE: X.X mm ± 0.5mm [X.XX in. ± 0.02in.]

X.XX mm ± 0.25mm[X.XXX in. ± 0.01in.]

Notes: 1.Dimensions within the box are critical dimensions

2. BDQ1300-48S12B-4LI-4 with pin8~11, BDQ1300-48S12B-4L-4 without pin8~11

3. The minimum clearance from customer PCB is 0.25mm[0.01in.]

4. Heatsink mounting holes(M3) permit max 3.0mm screw penetration depth into baseplate

Mechanical Specifications

Pin length option

Device code suffix	L
-4	4.6mm±0.25 mm
-6	3.8mm±0.25 mm
-8	2.8mm±0.25 mm
None	5.8mm±0.25 mm

Pin Designations

Pin No	Name	Function	Optional
1	Vin+	Positive input voltage	
2	Remote ON/OFF	Remote control	
3	Vin-	Negative input voltage	
4	Vo-	Negative output voltage	
5	Vo-	Negative output voltage	
6	Vo+	Positive output voltage	
7	Vo+	Positive output voltage	
8	Data	PMBus™ Data	Yes
9	Alert	PMBus™ Alert signal	
10	Clock	PMBus™ Clock	
11	Addr	PMBus™ Address	

Environmental Specifications

Input Fusing

Note: The fuse is fast blow type. An external fuse is recommended. To meet international safety requirements, a 170Vdc rated fuse should be used. Recommended rating is 125A for the converter.

EMC Immunity

The power supply is designed to meet the following EMC immunity specifications:

Table 6. EMC Requirement

Document	Description	Criteria
EN55032 DC input port, Class B Limits	Conducted Emission	/
IEC/EN 61000-4-2 Enclosure Port, Level 3	Immunity to Electrostatic Discharge	B
IEC/EN 61000-4-6, DC input port, Level 2	Immunity to Continuous Conducted Interference	A
IEC/EN 61000-4-4 DC input port, Level3	Immunity to Electrical Fast Transient	B
IEC/EN 61000-4-5 DC input port	Immunity to Surges Line to Ground(earth): 600V Line to Line: 600V	B
EN61000-4-29 DC input port	Immunity to Voltage Dips and Short Interruptions and Voltage Variations	B

Criterion A: Normal performance during and after test.
Criterion B: Output voltage fluctuation or reset is allowed during the test, but recovers to its normal performance automatically after the disturbance ceases.
Criterion C: Temporary loss of output, the correction of which requires operator intervention.
Criterion D: Loss of output which is not recoverable, owing to damage to hardware.

Environmental Specifications

Safety Certifications

The power supply is intended for inclusion in other equipment and the installer must ensure that it is in compliance with all the requirements of the end application. This product is only for inclusion by professional installers within other equipment and must not be operated as a stand alone product.

Table 7. Safety Certifications for The power supply system

Document	Description
UL/CSA62368-1	US and Canada Requirements
EN62368-1	European Requirements
IEC62368-1	International Requirements
CE	CE Marking
UL94	Materials meet V-0 flammability rating
TUV	International Requirements

Environmental Specifications

Thermal Considerations - Baseplate module

BDQ1300-48S12B is designed to operate in different thermal environments and sufficient cooling must be provided. Proper cooling can be verified by measuring the temperature at the test points as shown in the Figure 14. The temperature at these test points should not exceed the maximum values in Table 9.

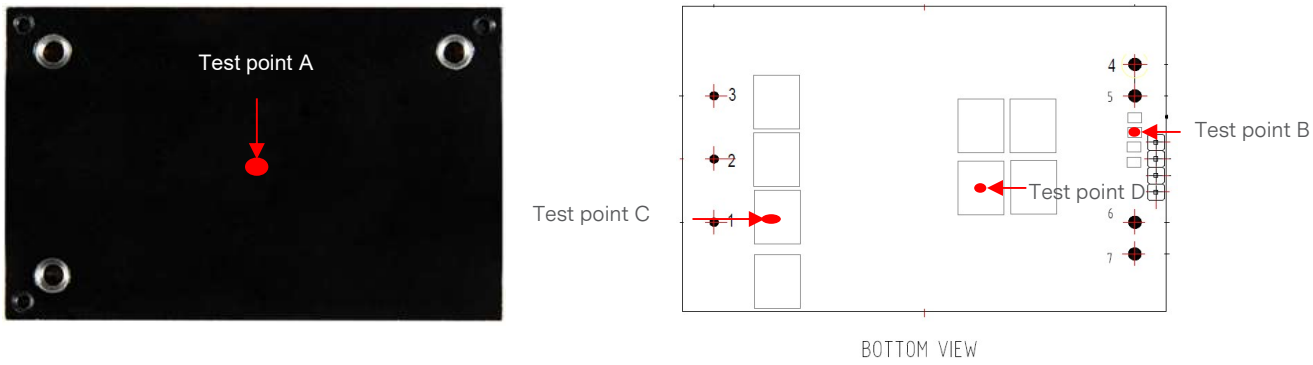


Figure 13 Temperature test point

Table 8. Temperature limit of the test point

Test Point	Temperature Limit (°C)
Test point A	109
Test point B	116
Test point C	122
Test point D	124

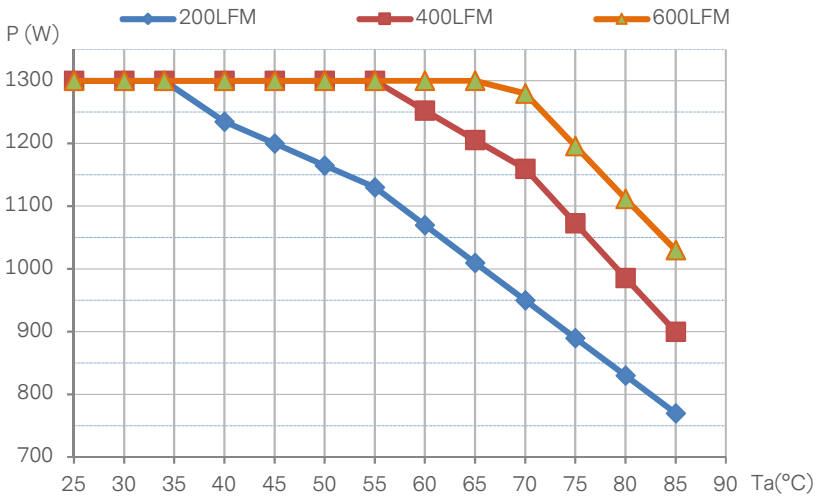


Figure 14 BDQ1300-48S12B, with baseplate, without heatsink, output power derating at 54Vin, air flowing across the converter from Vin- to Vin+

Environmental Specifications

Qualification Testing

Parameter	Unit (pcs)	Test condition
HALT test	2	Operating limit: Ta,min-20°C to Ta,max+25°C, 10°C step, $V_{IN,DC}$ = min to max, 0 ~ 100% load Vibration Limit: >30G.
Vibration	2	Frequency range: 5Hz ~ 20Hz, 20Hz ~ 200Hz, A.S.D: 1.0m2/s3, -3db/oct, axes of vibration: X/Y/Z. Time: 30min/axis, non operational
Mechanical Shock	2	Type: half sine, Acceleration: 30g, Duration: 6ms, Directions:6, Number of shock: 3times/face. Non Operational
Thermal Shock	3	-55°C to 125°C, Temp Dwell Time:30min, Temp change rate: 20°C/min, Unit temperature 20cycles
Thermal Cycling	3	-40°C to 85°C, temperature change rate: 1°C/min, cycles: 2cycles
Humidity	3	40°C, 95%RH, 48h
MTBF		Telcordia, SR332 Method 1 Case 1; 1.5MHrs Typically

Application Notes

Typical Application

Below is the typical application of the BDQ1300 series power supply.

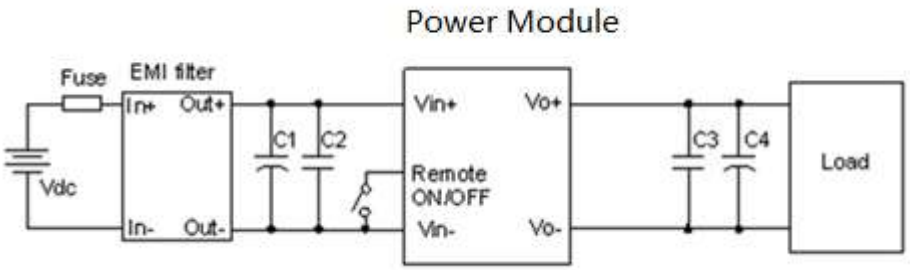


Figure 15 Typical application

C1: 220μF/100V electrolytic capacitor, P/N: Nichicon.

C2: 0.1μF/100V X7R ceramic capacitor.

C3: 1PCS 1μF/16V/X7S capacitor.

C4: 7*220μF/16V Polymer tantalum cap

Fuse: External fast blow fuse with a rating of 125A/170Vdc. The recommended fuse model is TLS125LR from Littefuse.

EMI Filter: refer to U1 in Figure 17.

Application Notes

Input Ripple & Inrush Current and Output Ripple & Noise Test Configuration

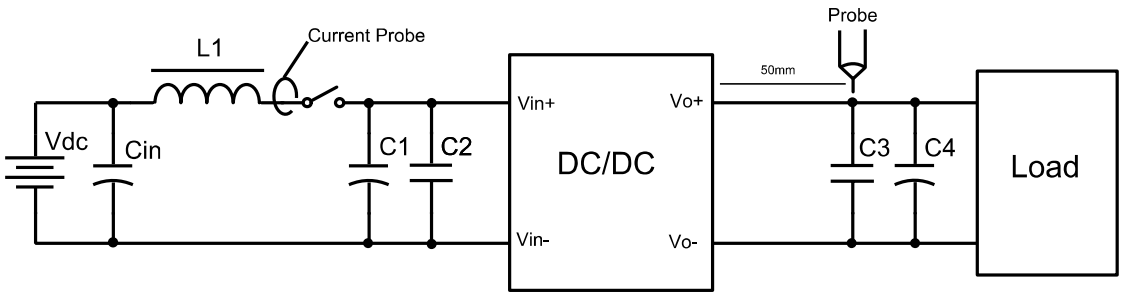


Figure 16 Input ripple & inrush current output ripple & noise test configuration

Vdc: DC power supply

L1: 12μH

Cin: 220μF/100V typical

C1~C4: See Figure 15

Note: Using a coaxial cable with a 50ohm termination resistor and 0.68μF ceramic capacitor in series to test output ripple & noise is recommended.

Application Notes

EMC test conditions

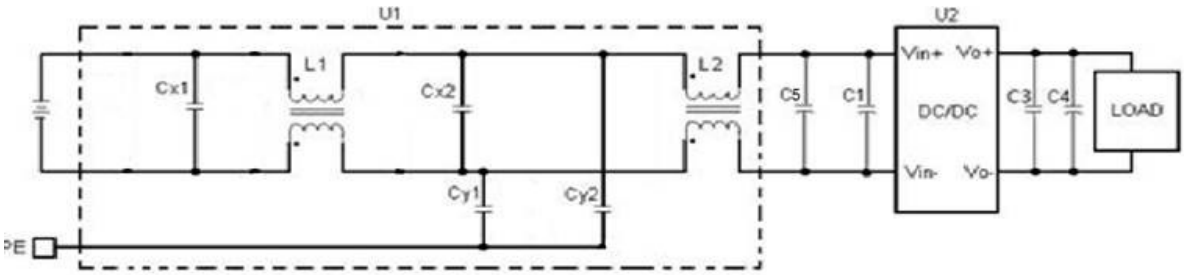


Figure 17 Typical application

C1: 220μF/100V electrolytic capacitor, P/N: Nichicon

C3: 1uF/16V/X7S *1 PCS capacitor

C4: 1000μF/16V electrolytic capacitor, P/N: OSK or POSCAP

U1: Input EMC filter

U2: Module to test

Cx1: 4*SMD ceramic-100V/4.7uF/X7R capacitor

Cx2: 4*SMD ceramic-100V4.7uF/X7R capacitor

Cy1: 2*SMD ceramic-630V/0.22uF/X7R Y capacitor

Cy2: 2*SMD ceramic-630V/0.22uF/X7R Y capacitor

L1, L2: 650uH, common mode inductor

Fuse: External fast blow fuse with a rating of 125A /170Vdc. The recommended fuse model is TLS125LR from Littefuse

Application Notes

Soldering

Generally, as the most common mass soldering method for the solder attachment, wave soldering is used for through-hole power modules and reflow soldering is used for surface-mount ones.

Reflow soldering is not a suggested method for through-hole power modules due to process challenges that can result in reduced module reliability. If you have this kind of application requirement, please contact sales or FAE for further information and recommendations.

Wave Soldering

When wave soldering is used, the temperature on pins is specified to maximum 255^{O}C for maximum 7s.

When soldering by hand, the iron temperature should be maintained at 300^{O}C ~ 380^{O}C and applied to the converter pins for less than 10s. Longer exposure can cause internal damage to the converter.

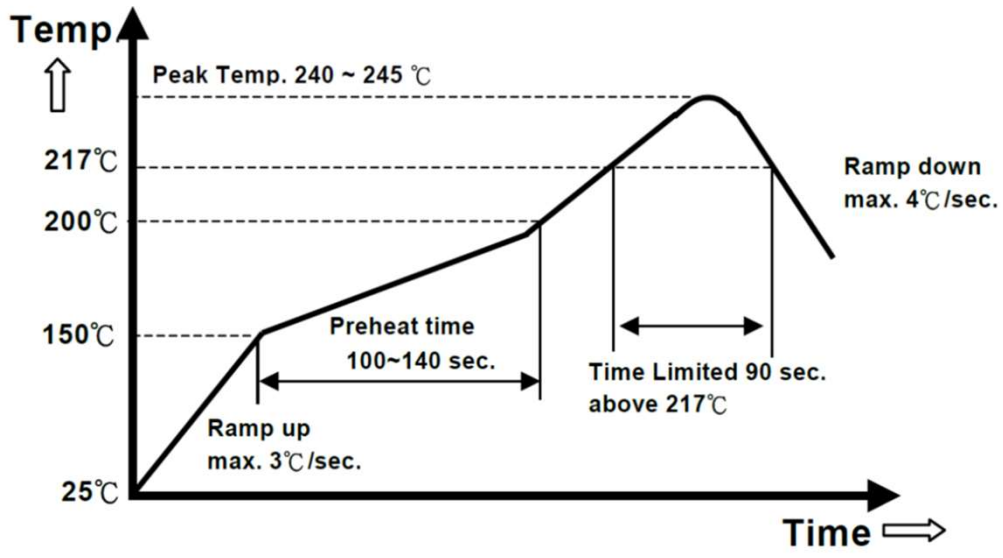
Cleaning of solder joint can be performed with cleaning solvent IPA or simulative.

Reflow Soldering

High temperature and long soldering time will result in IMC layer increasing in thickness and thereby shorten the solder joint lifetime. Therefore the peak temperature over 245^{O}C is not suggested due to the potential reliability risk of components under continuous high-temperature. In the meanwhile, the soldering time of temperature above 21OC should be less than 90 seconds.

Please refer to following fig for recommended temperature profile parameters.

Shielding cap is requested to mount on DCDC module if with heat-spreader/heat-sink, to prevent the customer side high temperature of reflow to re-melt the DCDC module's internal component's soldering joint.



Note: The temperature is measured on the pins of power module at the solder joint.

PMBus™ communication

Digital Feature Descriptions

The BDQ1300-48S12B-4LI is equipped with digital PMBus™ interface that allows the module to be configured and to communicate with a system controller. Detailed timing and electrical characteristics of the PMBus™ can be found in the PMB Power Management Protocol Specification, Part 1, revision 1.2, available at http://PMBUS.org.

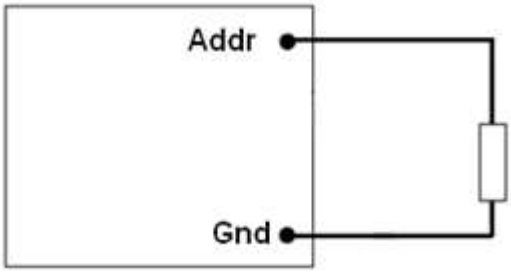
The module supports100 kHz bus timing requirements. The module shall stretch the clock, as long as it does not exceed the maximum clock LO period of 35ms. The module will check the Packet Error Checking scheme (PEC) byte, if provided by the PMBus™ master, and include a PEC byte in all responses to the master. However, the module does not require a PEC byte from the PMBus™ master.

The module supports a subset of the commands in the PMBus 1.2 specification. Most all of the controller parameters can be programmed using the PMBus™ and stored as defaults for later use. All commands that require data input or output use the linear format. The exponent of the data words is fixed at a reasonable value for the command and altering the exponent is not supported. Direct format data input or output is not supported by the module. The supported commands are described in greater detail below. The module contains non-volatile memory that is used to store configuration settings and scale factors. The settings programmed into the device are not automatically saved into this non-volatile memory though. The STORE_DEFAULT_ALL command must be used to commit the current settings to non-volatile memory as device defaults. The settings that are capable of being stored in non-volatile memory are noted in their detailed descriptions.

PMBus™ communication

PMBusTM Addressing

The module has flexible PMBus™ addressing capability. By connecting different resistors from Addr pin to GND pin, 14 possible addresses can be acquired. The 7 bit PMBus™ address is defined by the value of the resistor as shown in the table below, and +/- 1% resistor accuracy is acceptable. If there is any resistance exceeding the requested range, address 127 will be returned.



PMBusTM Address	Resistor (Kohm)
96	10
97	15
98	21
99	28
100	35.7
101	45.3
102	56.2
103	69.8
104	88.7
105	107
106	130
107	158
108	191
109	232

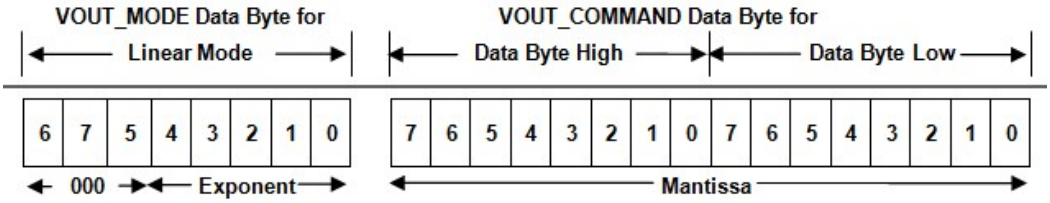
PMBus™ communication

Black Box

There is a black box function realized by 21 pages of D-flash, which has 20K erase cycles up to 120C hotspot temp; the first page is used to save the page number which records the newest history event. Total 20 pages and 19 byte per page, are assigned to record 20 history events. Vin UVLO event is not record in black box. Fault time means the time to Vo turn on.

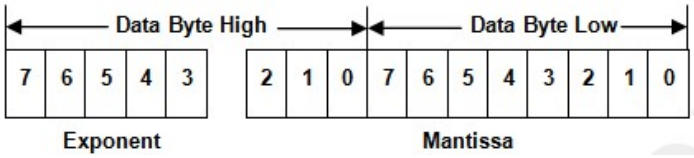
PMBus™ Data Format

For commands that set or report any voltage thresholds related to output voltage (including VOUT_COMMAND, VOUT_MARGIN, POWER_GOOD and READ_VOUT), the module supports the linear data format consisting of a two byte value with a 16-bit, unsigned mantissa, and a fixed exponent of -12. The format of the two data bytes is shown below:



The value of the number is then given by Value = Mantissa x 2^{-12}

For commands that set all other thresholds, voltages or report such quantities, the module supports the linear data format consisting of a two byte value with an 11-bit, two's complement mantissa and a 5-bit, two's complement exponent. The format of the two data bytes is shown below:



The value is of the number is then given by Value = Mantissa x 2^{Exponent}

PMBus™ Enabled On/Off

The module can also be turned on and off via the PMBus™ interface. The OPERATION command is used to actually turn the module on and off via the PMBus™, Bit [7] in the OPERATION command data byte enables the module, with the following functions:

0 : Output is disabled
1 : Output is enabled

PMBus™ communication

PMBus™ Adjustable Input Under voltage Lockout

The module allows adjustment of the input under voltage lockout and hysteresis. The command VIN_ON allows setting the input voltage turn on threshold, while the VIN_OFF command sets the input voltage turn off threshold. For both the VIN_ON and VIN_OFF commands, possible values range from 34.000 to 40.000V in 0.125V steps. VIN_ON must be 1.5V greater than VIN_OFF.

Both the VIN_ON and VIN_OFF commands use the “Linear” format with two data bytes. The upper five bits [7:3] of the high data byte form the two’s complement representation of the exponent, which is fixed at –3 (decimal). The remaining 11 bits are used for two’s complement representation of the mantissa, with the 11th bit fixed at zero since only positive numbers are valid. The data associated with VIN_ON and VIN_OFF can be stored to non-volatile memory using the STORE_DEFAULT_ALL command. The data associated with VIN_ON and VIN_OFF can be stored to non-volatile memory using the STORE_DEFAULT_ALL command.

PMBus™ Adjustable Soft Start Delay and Rise Time

The soft start delay and rise time can be adjusted in the module via PMBus™. The TON_DELAY command sets the delay time in ms, and allows choosing delay times between 10ms and 500ms, with resolution of 0.5ms. The TON_RISE command sets the rise time in ms, and allows choosing soft start times between 20ms and 500ms, with resolution of 0.5ms. When setting TON_RISE, make sure that the charging current for output capacitors can be delivered by the module in addition to any load current to avoid nuisance tripping of the over current protection circuitry during startup. Both the TON_RISE and TON_DELAY commands use the “Linear” format with two data bytes. The upper five bits [7:3] of the high data byte form the two’s complement representation of the exponent, which is fixed at –1 (decimal). The remaining 11 bits are used for two’s complement representation of the mantissa, with the 11th bit fixed at zero since only positive numbers are valid. The data associated with TON_RISE and TON_DELAY can be stored to non-volatile memory using the STORE_DEFAULT_ALL command.

Output Voltage Adjustment Using the PMBus™

The module output voltage set point is adjusted using the VOUT_COMMAND. The output voltage setting uses the Linear data format, with the 16 bits of the VOUT_COMMAND formatted as an unsigned mantissa, and a fixed exponent of -12 (decimal) (read from VOUT_MODE).

$$VOUT = Mantissa \times 2^{-12}$$

The range limits for VOUT_COMMAND are 10.8V-12.2V and the resolution is 0.244mV . The data associated with VOUT_COMMAND can be stored to non-volatile memory using the STORE_DEFAULT_ALL command.

Output Voltage Margining Using the PMBus™

The module can also have its output voltage margined via PMBus™ commands. The command VOUT_MARGIN_HIGH sets the margin high voltage, while the command VOUT_MARGIN_LOW sets the margin low voltage. Both the VOUT_MARGIN_HIGH and VOUT_MARGIN_LOW commands use the “Linear” mode with the exponent fixed at –12 (decimal). The data associated with VOUT_MARGIN_HIGH and VOUT_MARGIN_LOW can be stored to non-volatile memory using the STORE_DEFAULT_ALL command. The module is commanded to go to the margined high or low voltages using the OPERATION command. Bits [5:2] are used to enable margining as follows:

00XX	Margin Off
0110	Margin Low (Act on Fault)
1010	Margin High (Act on Fault)

PMBus™ communication

Measuring Input Voltage Using the PMBus™

The module can provide input voltage information using the READ_VIN command. The command returns two bytes of data in the linear format. The upper five bits [7:3] of the high data byte form the two's complement representation of the

exponent, which is fixed at –3 (decimal). The remaining 11 bits are used for two's complement representation of the mantissa, with the 11th bit fixed at zero since only positive numbers are valid.

Measuring Input Current Using the PMBus™

The module can provide input current information using the READ_IIN command. The command returns two bytes of data in the linear format. The upper five bits [7:3] of the high data byte form the two's complement representation of the

exponent, which is fixed at –2 (decimal). The remaining 11 bits are used for two's complement representation of the mantissa, with the 11th bit fixed at zero since only positive numbers are valid.

Measuring Output Voltage Using the PMBus™

The module can provide output voltage information using the READ_VOUT command. The command returns two bytes of data in the linear format, with the 16 bits of the READ_VOUT formatted as an unsigned mantissa, and a fixed exponent of -12 (decimal).

Measuring Output Current Using the PMBus™

The module measures output current by using the output filter inductor winding resistance as a current sense element. The module can provide output current information using the READ_IOUT command. The command returns two bytes of data in the linear format. The upper five bits [7:3] of the high data byte form the two's complement representation of the exponent, which is fixed at –2 (decimal). The remaining 11 bits are used for two's complement representation of the mantissa, with the 11th bit fixed at zero since only positive numbers are valid. The READ_IOUT command provides module average output current information. This command only supports positive current sourced from the module. If the converter is sinking current a reading of 0 is provided.

PMBus™ communication

Measuring the Temperature using the PMBus™

The module can provide temperature information using the READ_TEMPERATURE_1 command. The command returns two bytes of data in the linear format. The upper five bits [7:3] of the high data byte form the two's complement representation of the exponent, which is fixed at –2 (decimal). The remaining 11 bits are used for two's complement representation of the mantissa. Note that the module's temperature sensor is located close to the module hot spot OTP test point (see Figure 10) and is subjected to temperatures higher than the ambient air temperature near the module. The temperature and temperature reading will be highly influenced by module load and airflow conditions.

Reading the Status of the Module using the PMBus™

The module supports a number of status information commands implemented in PMBus™ . However, not all features are supported in these commands. A X in the FLAG cell indicates the bit is not supported.
STATUS_WORD: Returns two bytes of information with a summary of the module's fault/warning conditions.

High Byte

Bit Position	Flag	Default Value
15	VOUT fault	0
14	IOUT fault or warning	0
13	Input Voltage fault	0
12	X	0
11	X	0
10	X	0
9	X	0
8	X	0

Low Byte

Bit Position	Flag	Default Value
7	X	0
6	OFF	0
5	VOUT Over voltage	0
4	IOUT Over current	0
3	VIN Under voltage	0
2	Temperature	0
1	CML(Command)	0
0	X	0

PMBus™ communication

STATUS_VOUT: Returns one byte of information relating to the status of the module's output voltage related faults.

Bit Position	Flag	Default Value
7	VOUT OV Fault	0
6	Output over voltage warning	0
5	X	0
4	X	0
3	X	0
2	X	0
1	X	0
0	X	0

STATUS_IOUT: Returns one byte of information relating to the status of the module's output current related faults.

Bit Position	Flag	Default Value
7	IOUT OC Fault	0
6	X	0
5	IOUT OC Warning	0
4	X	0
3	X	0
2	X	0
1	X	0
0	X	0

STATUS_INPUT: Returns one byte of information relating to the status of the module's input voltage related faults.

Bit Position	Flag	Default Value
7	VIN OV Fault	0
6	Input over voltage warning	0
5	Input under voltage warning	0
4	VIN UV Fault	0
3	X	0
2	X	0
1	X	0
0	X	0

PMBus™ communication

STATUS_TEMPERATURE: Returns one byte of information relating to the status of the module's temperature related faults.

Bit Position	Flag	Default Value
7	OT Fault	0
6	OT Warning	0
5	X	0
4	X	0
3	X	0
2	X	0
1	X	0
0	X	0

ALL of the warning or fault bits set in the status registers remain set, even if the fault or warning condition is removed or corrected, until one of the following occur:
1) The bit is individually cleared;
2) The device receives a CLEAR_FAULTS command;
3) Bias power is removed from the module.

Summary of Supported PMBus™ Commands

This section outlines the PMBus™ command support for this bus converter. Each supported command is outlined in order of increasing command codes with a quick reference table of all supported commands included at the end of the section. Each command will have the following basic information.

Command Name [Code]

Command support
Additional information may be provided in tabular form or other format, if necessary.

PMBus™ communication

OPERATION [0x01]

Command support: On/Off Immediate

Bit number	Purpose	Bit Value	Meaning
7	Enable/Disable the module	1	Output is enabled
		0	Output is disabled
6	Reserved		
5:3	Vout Command	011	Margin Low (Act on Fault)
		101	Margin High(Act on Fault)
2:0	Reserved		

CLEAR_FAULTS [0x03]

Command support: All functionality

WRITE PROTECTION [0x10]

Bit number	Purpose	Bit Value	Meaning
7	Enable/Disable the protection	1	Protection is enabled
6:0	Reserved	0	Protection is disabled

STORE_DEFAULT_ALL[0x11]

Command support: All functionality – Stores operating parameters to E^2prom memory.

RESTORE_DEFAULT_ALL[0x12]

Command support: All functionality – Restores operating parameters from E^2prom memory.

VOUT_MODE[0x20]

Command support: Supported. Factory default: 0x14 – indicates linear mode with exp = -12.

Format	8 bit unsigned (bit field)							
Bit Position	7	6	5	4	3	2	1	0
Access	r	r	r	r	r	r	r	r
Function	Mode(linear)			2's complement exponent				
Default Value	0	0	0	1	0	1	0	0

PMBus™ communication

VOUT_COMMAND [0x21]

Data format: 16 bit unsigned mantissa (implied exponent per VOUT_MODE)
Factory default: 12.170V (12.17 / 2-12 → 49,848 = 0xC2B8)
Range limits (max/min): 12.5/10.8V(Vin=54~60V)
Units: volt

VOUT_MARGIN_HIGH [0x25]

Range limits (max/min): 12.5/10.8V(Vin=54~60V)

Units: volt
Command support: read/write support, full functionality except “Ignore faults”.
Note: Range cross-check - value must be greater than VOUT_MARGIN_LOW value.

VOUT_MARGIN_LOW [0x26]

Range limits (max/min): 12.5/10.8V(Vin=54~60V)

Units: volt
Command support: read/write support, full functionality except “Ignore faults”.
Note: Range cross-check - value must be less than VOUT_MARGIN_HIGH value.

VIN_ON [0x35]

Range limits (max/min): 40/35
Units: volt
Command support: All functionality
Note: Special interlock checks between VIN_ON and VIN_OFF maintain a hysteresis gap of 1.5V minimum and do not allow the OFF level to be higher than and ON level

VIN_OFF [0x36]

Range limits (max/min): 39/34
Units: volt
Command support: All functionality
Note: Special interlock checks between VIN_ON and VIN_OFF maintain a hysteresis gap of 1.5V minimum and do not allow the OFF level to be higher than and ON level

VOUT_OV_FAULT_LIMIT [0x40]

Range limits (max/min): 14.5/13 (See note 2)
Units: volt
Command support: All functionality
Note:
1. Range cross- check – value must be greater than VOUT_COMMAND value.
2. The maximum OV Fault Limit equals the output set point plus 2.3V, up to 14.5V. This is an automatic module protection feature that will override a user-set fault limit if the user limit is set too high.

PMBus™ communication

IOUT_OC_FAULT_LIMIT [0x46]

Range limits (max/min): 170/150
Units: amp
Command support: All functionality
Note: Range cross-check – value must be greater than IOUT_OC_WARN_LIMIT value.

IOUT_OC_WARN_LIMIT [0x4A]

Range limits (max/min): 155/145
Units: amp
Command support: read/write support, functionality complete
Note: Range cross-check – value must be less than IOUT_OC_FAULT_LIMIT value.

OT_FAULT_LIMIT [0x4F]

Range limits (max/min): 140/25
Units: degrees C.
Command support: All functionality
Note: Range cross-check – value must be greater than OT_WARN_LIMIT value.

OT_WARN_LIMIT [0x51]

Range limits (max/min): 120/25
Units: degrees C.
Command support: All functionality
Note: Range cross-check – value must be less than OT_FAULT_LIMIT value.

VIN_OV_FAULT_LIMIT [0x55]

Range limits (max/min): 68/61
Units: volt
Command support: All functionality

PMBus™ communication

STATUS_WORD [0x79]

Command support: full implementation for supported functions

Format	8 bit unsigned (bit field)							
Bit Position	15	14	13	12	11	10	9	8
Access	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset
Function	VOUT	IOUT	INPUT	Reserved	Reserved	Reserved	Reserved	Reserved

Format	8 bit unsigned (bit field)							
Bit Position	7	6	5	4	3	2	1	0
Access	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset
Function	Reserved	OUTPUT_OFF	VOUT_OV_FAULT	IOUT_OC_FAULT	VIN_UV_FAULT	TEMP	CML	Reserved

STATUS_VOUT [0x7A]

Command support: VOUT_OV_FAULT support, all bit reset supported

Format	8 bit unsigned (bit field)							
Bit Position	7	6	5	4	3	2	1	0
Access	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset
Function	VOUT_OV_FAULT	VOUT_OV_WARN	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved

STATUS_IOUT [0x7B]

Command support: IOUT_OC_FAULT and IOUT_OC_WARN support, all bit reset supported.

Format	8 bit unsigned (bit field)							
Bit Position	7	6	5	4	3	2	1	0
Access	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset
Function	IOUT_OC_FAULT	Reserved	IOUT_OC_WARN	Reserved	Reserved	Reserved	Reserved	Reserved

PMBus™ communication

STATUS_INPUT [0x7C]

Command support: VIN_OV_FAULT， VIN_OV_WARN， VIN_UV_WARN and VIN_UV_FAULT support, all bit reset supported

Format	8 bit unsigned (bit field)							
Bit Position	7	6	5	4	3	2	1	0
Access	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset
Function	VIN_OV_FAULT	VIN_OV_WARN	VIN_UV_WARN	VIN_UV_FAULT	Reserved	Reserved	Reserved	Reserved

STATUS_TEMPERATURE [0x7D]

Command support: OT_WARN, OT_FAULT supported, all bit reset supported

Format	8 bit unsigned (bit field)							
Bit Position	7	6	5	4	3	2	1	0
Access	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset
Function	OT_FAULT	OT_WARN	Reserve	Reserve	Reserved	Reserved	Reserved	Reserved

STATUS_CML[0x7E]

Format	8 bit unsigned (bit field)							
Bit Position	7	6	5	4	3	2	1	0
Access	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset	r/reset
Function	Invalid/Unsupported Command Received	Invalid/Unsupported Data Received	Packet Error Check Failed	Reserve	Reserved	Reserved	Reserved	Reserved

PMBus™ communication

READ_VIN [0x88]

Command support: full support

READ_IIN [0x89]

Command support: full support

READ_VOUT [0x8B]

Command support: full support

READ_IOUT [0x8C]

Command support: full support

READ_TEMPERATURE_1 [0x8D]

Command support: full support

PMBUS_REVISION[0x98]

Command support: full read support

PMBUS_CMD_MFR_ID [0x99]

Command support: full read support

PMBUS_CMD_MFR_MODEL [0x9A]

Command support: full read support

MFR_FW_REV [0x9B]

Command support: full read support

PMBUS_CMD_MFR_LOCATION [0x9C]

Command support: full read/write support

PMBUS_CMD_MFR_SERIAL [0x9E]

Command support: full read/write support

BLACKBOX_EN[0xDF]

Bit number	Purpose	Bit value	Meaning
7:1	Reserved		
0	Enable/Disable the Black box overwrite function	1	Overwrite function is enabled
		0	Overwrite function is disabled

If overwrite function is disabled, black box only record 20 faults, then it will lock and no more faults will be recorded. If overwrite function is enabled, when fault log is full, the new fault will overwrite the previous fault, starting from entry 1.

HISTORY EVENT READ SECTION:
0xE1 command: Write the Offset Value to Slave to decide which history data for read.
0XE0 command: read the history data after 0xE1 command

PMBus™ communication

BDQ1300-48S12B Series Support PMBus™ Command List

The BDQ1300 series power supply is compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the i2C interface port.

BDQ1300-48S12B Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
01h	OPERATION	80	R/W	1	Bit field	Used to turn the unit ON/OFF
03h	CLEAR_FAULTS	-	Send	1	N/A	Clear any fault bits that have been set
10h	WRITE_PROTECTION	Clear 00	R/W	1	Bit field	Set or Clear the bit of Write protection
79h	STATUS_WORD	-	R	2	Bit field	Returns the information with a summary of the module's fault/warning
7Ah	STATUS_VOUT	-	R	1	Bit field	Returns the information of the module's output voltage related fault/warning
7Bh	STATUS_IOUT	-	R	1	Bit field	Returns the information of the module's output current related fault/warning
7Ch	STATUS_INPUT	-	R	1	Bit field	Returns the information of the module's input over voltage and under voltage fault
7Dh	STATUS_TEMPERATURE	-	R	1	Bit field	Returns the information of the module's temperature related fault/warning
7Eh	STATUS_CML	-	R	1	Bit field	Returns the information of the module's communication related faults
88h	READ_VIN	-	R	2	Linear	Returns the input voltage of the module
89h	READ_IIN	-	R	2	Linear	Calculated by P-OUT, according to the efficiency curve
8Bh	READ_VOUT	-	R	2	VOUT Linear	Returns the output voltage of the module
8Ch	READ_IOUT	-	R	2	Linear	Returns the output current of the module
8Dh	READ_TEMP1	-	R	2	Linear	Returns the module's temperature sensor temperature
98h	PMBUS_REVISION	-	R	1	Bit field	Read the version of the PMBUS
99h	PMBUS_CMD_MFR_ID	-	R		Char	Returns the Artesyn
9Ah	PMBUS_CMD_MFR_MODEL	-	R		Char	Returns the name of the module
9Bh	MFR_FW_REV	-	R		Char	Returns the version of the software
9Ch	MFR_MOD_DATE_LOC_SN	-	R/W		Char	Returns the production's place of the module
9Eh	PMBus_CMD_MFR_SERIAL	-	R/W		Char	Returns the serial number of the module
E0h	READ_HISTORY EVENTS		Read Block		NA	Max 20 events, 20 commands
E1h	SET_HISTORY_EVENT_OFFSET		R/W		NA	Max 20 events, 20 commands

PMBus™ communication

READ HISTORY EVENT OFFSET (0XE1):

Send command 0XE1 and read one byte, it will return the next event log offset value x.

Start	Device Address & R/W	Command byte(0XE1)	Repeated Start	Device Address & R/W

Event log offset value	PEC	Stop

SET HISTORY EVENT OFFSET [0XE1]

Then send command 0XE1 and write the offset value x-1, if send command 0XE0 to read data after this write command 0XE1, the last event data will be read back. The maximum value of the offset is 20, if the history data is large than 20, it will recount from 20 to 0.

Start	Device Address & R/W	Command byte(0XE1)	Offset value	PEC	Stop

READ_HISTORY EVENTS [0xE0]

Start	Device Address & R/W	Command byte(0XE0)	Repeated Start	
Device Address & R/W	EVENT#	Status_Word_High_Byte	Status_Word_Low_Byte	Status_Vout
Status_Iout	Status_Input	Status_Temperature	Status_cml	Vin_data_high_byte
Vin_data_low_byte	Vout_data_high_byte	Vout_data_low_byte	Iout_data_high_byte	
Iout_data_low_byte	temperature_data_high_byte	temperature_data_low_byte	Fault time_first_byte	
Fault time_second_byte	Fault time_third_time	Fault time_fourth_byte	PEC	Stop

Record of Revision and Changes

Issue	Date	Description	Originators
1.0	11.07.2019	First Issue	K. Wang
1.1	12.04.2019	Update the picture for cover page and page 14	K. Wang
1.2	06.22.2020	Update format issue	K. Wang

ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

PRECISION | POWER | PERFORMANCE

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