TECHNICAL REFERENCE NOTE

ARTESYN NDQ900-48S12B

900 Watts Non-Isolated Quarter-brick Converter

PRODUCT DESCRIPTION

Advanced Energy's Artesyn NDQ900-48S12B-6LI is a new generation non-isolated single output digital control DC/DC converter with standard quarter-brick outline and pin configuration, as well as PMBus™ option. It delivers up to 900 W with 12.25 V output voltage. Ultra high peak efficiency of 96.7% and excellent thermal performance makes it an ideal choice for 48 V to 12 V down conversion in high power computing and storage applications. It can produce full power over an operating temperature range of -40°C to +85°C with forced air cooling. PMBus™ interface is also provided for flexible digital control and monitoring.

AT A GLANCE

Total Power

900 Watts

Input Voltage

40 to 60 Vdc

# of Outputs

Single

RoHS

PMBus® Power Management. Defined.

SPECIAL FEATURES

- Delivering up to 900 W
- Ultra-high efficiency 96.7% peak
- Wide input range: 40 to 60 Vdc
- PMBus™ function
- Excellent thermal performance
- Parallel operation, active current sharing
- Power good function
- No minimum load requirement
- Fixed switching frequency
- Baseplate for contact cooling
- RoHS 3.0
- Remote control function
- Input undervoltage lockout
- Input overvoltage lockout
- Output overcurrent protection
- Output overvoltage protection
- Over temperature protection
- Pin length option: 3.8 mm

SAFETY

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

TYPICAL APPLICATIONS

- Telecom
- Datacom
- Computing and storage

MODEL NUMBERS

Part number	Output Voltage	Structure	Pin Type	RoHS Status	PMBus™
NDQ900-48S12B-6LI	12.25 Vdc	Baseplate	Through hole	RoHS 3.0	Yes

Order Information

NDQ900	-	48	S	12		B	-	6	L	I	H	
①		②	③	④	⑤	⑥		⑦	⑧	⑨	⑩	⑪

①	Model series	NDQ: high efficiency non-isolated digital control quarter brick series 900: output power 900 W
②	Input voltage	48: 40 to 60 V input range, rated input voltage 50 V
③	Output number	S: single output
④	Rated output voltage	12: 12.25 V output
⑤	Enable polarity	Blank: negative logic; P: positive enable
⑥	Baseplate status	B: with baseplate
⑦	Pin length	-6: 3.8 mm, -4: 4.8 mm
⑧	RoHS status	L: RoHS 3.0
⑨	PMBus™ interface pins	I: I-share pin, PMBus pins and PG-pin; Blank: no I-share pin, PMBus pins or PG-pin.
⑩	Power pin config	Blank: single pair of power pins; H: double pair of power pins
⑪	Customization code	TBD

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 Non-operating 100ms	All	$V_{IN,DC}$	 40 40	 - -	 60 80	 Vdc Vdc
Maximum Output Power[1]	All	$P_{O,max}$	-	-	900	W
Ambient Operating Temperature	All	T_A	-40	-	+85	^{O}C
Storage Temperature	All	T_{STG}	-55	-	+125	^{O}C
Humidity (non-condensing) Operating Non-operating	All		 - -	 - -	 95 95	 % %

Note 1 – 1000 W / 50 ms peak power. When peak power occurs, the average power with peak power will not exceed 900 W.

ELECTRICAL SPECIFICATIONS

Input Specifications

Table 2. Input Specifications (Tested with the Application Circuit as Figure 12)

Parameter		Conditions[1]	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC		All	$V_{IN,DC}$	40	50	60	Vdc
Input Under Voltage Lockout	Turn-on Voltage Threshold	All	$V_{IN,ON}$	35	-	40	Vdc
	Turn-off Voltage Threshold	All	$V_{IN,OFF}$	34	-	39	Vdc
	Lockout Voltage Hysteresis	All		1	-	3.5	Vdc
Input Overvoltage Protection		All		61	-	68	Vdc
Maximum Input Current		$V_{IN,DC}$ = 40 Vdc, $I_O = I_{O,max}$	$I_{IN,max}$	-	-	24.3	A
No Load Input Current		All	I_{IN,no_load}	-	0.18	-	A
Standby Input current		Remote OFF	$I_{IN,standby}$	-	0.02	-	A
Recommended Input Fuse		Fast blow external fuse is recommended		-	-	50	A
Input Reflected Ripple Current (RMS)[2]		Through 12 uH inductor		-	50	-	mA
Recommended External Input Capacitance		Low ESR capacitor is recommended	C_{IN}	300	-	-	uF
Operating Efficiency		$V_{IN,DC}$ = 50 Vdc, T_A = 25°C Airflow = 1200 LFM I_O = 100% $I_{O,max}$ I_O = 70% $I_{O,max}$	η	- -	96.4 96.7	- -	% %

Note 1 - T_A = 25°C, Vin = 50 Vdc, nominal Vout unless otherwise noted.
Note 2 - Input Reflected Ripple Current (RMS), tested with the circuit as Figure 13 on page 14.

ELECTRICAL SPECIFICATIONS

Output Specifications

Table 3. Output Specifications (Tested with the Application Circuit as Figure 12)

Parameter		Conditions[1]	Symbol	Min	Typ	Max	Unit
Factory Voltage Set Point		$V_{IN,DC}$ = 50 Vdc I_O = 50%$I_{O,max}$	V_O	12.10	12.25	12.35	Vdc
Output Voltage Line Regulation		All	V_O	-	60	-	mV
Output Voltage Load Regulation		All	V_O	-	200	-	mV
Output Voltage Temperature Regulation		All	V_O	-	-	0.02	%/^{O}C
Total Regulation		Over set point, line, load, temperature & life	V_O	11.50	-	12.95	Vdc
Output Voltage Ripple and Noise, pk-pk See Figure 13 for the setup		Measured with a 0.68 uF output cap. to 20 MHz bandwidth; Figure 13	V_O	-	50	-	mV_{PK-PK}
Output Current		All	I_O	0	-	73.7	A
Output DC Current-limit Inception[2]		All	I_O	80	-	127	A
V_O Load Capacitance		All	C_O	590	-	6000	uF
V_O Dynamic Response	Peak Deviation Settling Time	50% to 75% to 50% $I_{O,max}$ Slew rate = 0.1 A/us	$\pm V_O$ T_s	- -	200 300	- -	mV us
Turn-on Transient	Rise Time	I_O = $I_{O,max}$	T_{rise}	-	-	50	mS
	Turn-on Delay Time	By DC input	$T_{turn-on}$	-	-	200	mS
	Turn-on Delay Time	By enable	$T_{turn-on}$	-	-	200	mS
	Turn-on Overshoot	All	V_O	-	-	600	mV
	Turn-off Undershoot	All	V_O	-	-	600	mV
Remote ON/OFF Control (Negative logic)[3]	Off-state Voltage	All		2.4	-	15	Vdc
	On-state Voltage	All		-0.3	-	0.8	Vdc
Power Good Function (Negative logic)[4]	Power Good State	All		-0.3	-	0.8	Vdc
	Power NOT-good State	All		2.4	-	5	Vdc
Output Overvoltage Protection[5]		All		13.7	-	18.5	Vdc
Output Over Temperature Protection[6]		Baseplate	T	95	-	135	^{O}C
Switching Frequency		All	f_{SW}	-	165	-	kHz
Logic Pin Voltage[7]		All		-0.3	-	3.6	Vdc

Note 1 - T_A = 25 ^{O}C, Vin = 50 Vdc, nominal Vout unless otherwise noted.
Note 2 - Hiccup: auto-restart when overcurrent condition is removed.
Note 3 - Negative logic default, positive available.
Note 4 - The power good function will exhibit a logic-low when the unit is operating correctly, and a logic-high when the unit is in fault condition and not supplying power. The power good function is open drain, with external pull-up resistor.
Note 5 - Hiccup: auto-restart when overvoltage condition is removed.
Note 6 - Auto recovery. Temperature protect (OTP) test point is the middle of baseplate.
Note 7 - Such as Addr, Clock, Data, SMBAlert signal. Voltage reference to Sig_gnd or Vo-.

ELECTRICAL SPECIFICATIONS

NDQ900-48S12B-6LI Performance Curves

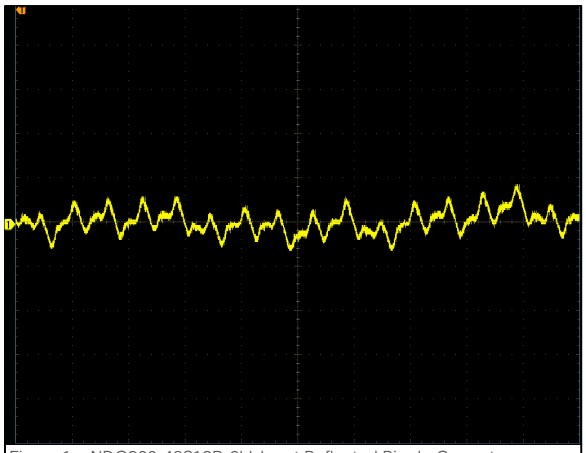


Figure 1: NDQ900-48S12B-6LI Input Reflected Ripple Current
Vin = 50 Vdc Load: Io = 73.7 A
Ch 1: Iin (10uS/div, 5mA/div)

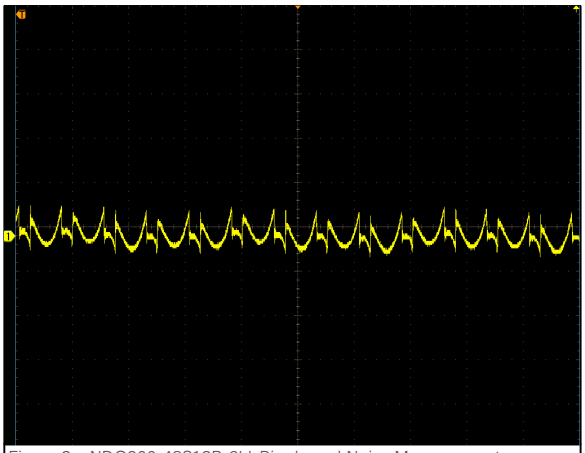


Figure 2: NDQ900-48S12B-6LI Ripple and Noise Measurement
Vin = 50 Vdc Load: Iout = 73.7 A
Ch 1: Vout (4uS/div, 20mV/div)

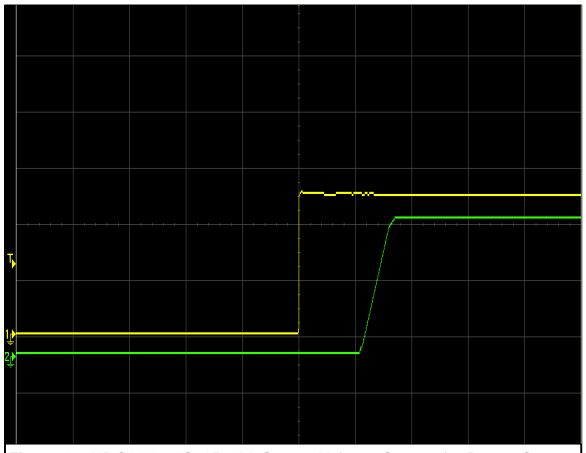


Figure 3: NDQ900-48S12B-6LI Output Voltage Startup by Power On
Vin = 50 Vdc Load: Iout = 73.7 A
Ch 1: Vin (20V/div) Ch 2: Vout (5V/div) (50mS/div)

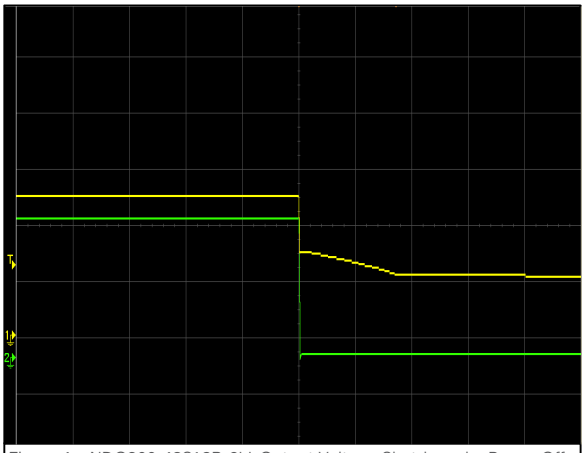


Figure 4: NDQ900-48S12B-6LI Output Voltage Shutdown by Power Off
Vin = 50 Vdc Load: Iout = 73.7 A
Ch 1: Vin (20V/div) Ch 2: Vout (5V/div) (50mS/div)

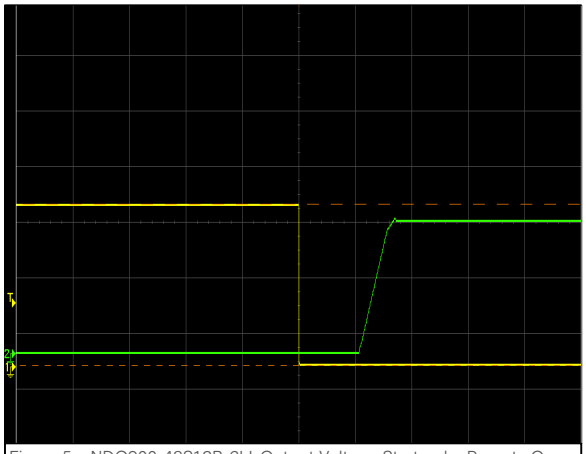


Figure 5: NDQ900-48S12B-6LI Output Voltage Startup by Remote On
Vin = 50 Vdc Load: Iout = 73.7 A
Ch 1: Remote on (1V/div) Ch 2: Vout (5V/div) (50mS/div)

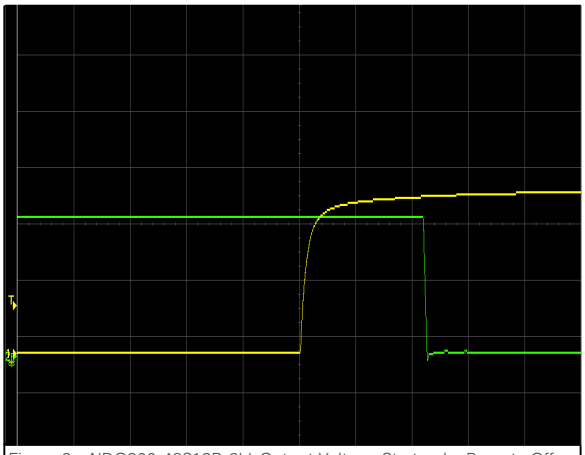


Figure 6: NDQ900-48S12B-6LI Output Voltage Startup by Remote Off
Vin = 50 Vdc Load: Iout = 73.7 A
Ch 1: Remote off (1V/div) Ch 2: Vout (5V/div) (10mS/div)

ELECTRICAL SPECIFICATIONS

NDQ900-48S12B-6LI Performance Curves

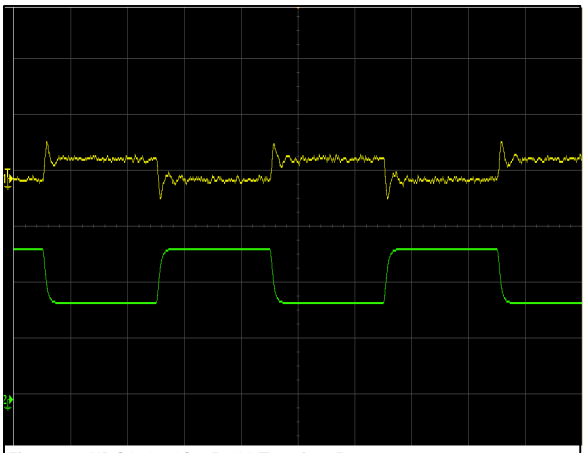


Figure 7: NDQ900-48S12B-6LI Transient Response
Vin = 50 Vdc Iout = 50% to 75% to 50%, 0.1 A/uS
Ch 1: Vout (100mV/div) Ch 2: Iout (20A/div)

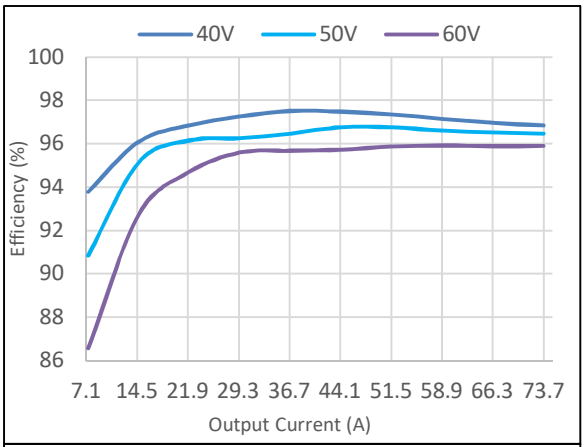


Figure 8: NDQ900-48S12B-6LI Efficiency Curves @ 25°C, 800 LFM
Vin = 40 to 60 Vdc
Loading: Io = 10% increment to 73.7 A

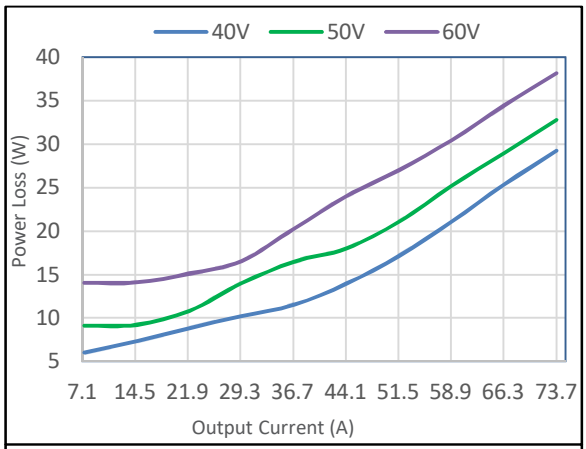
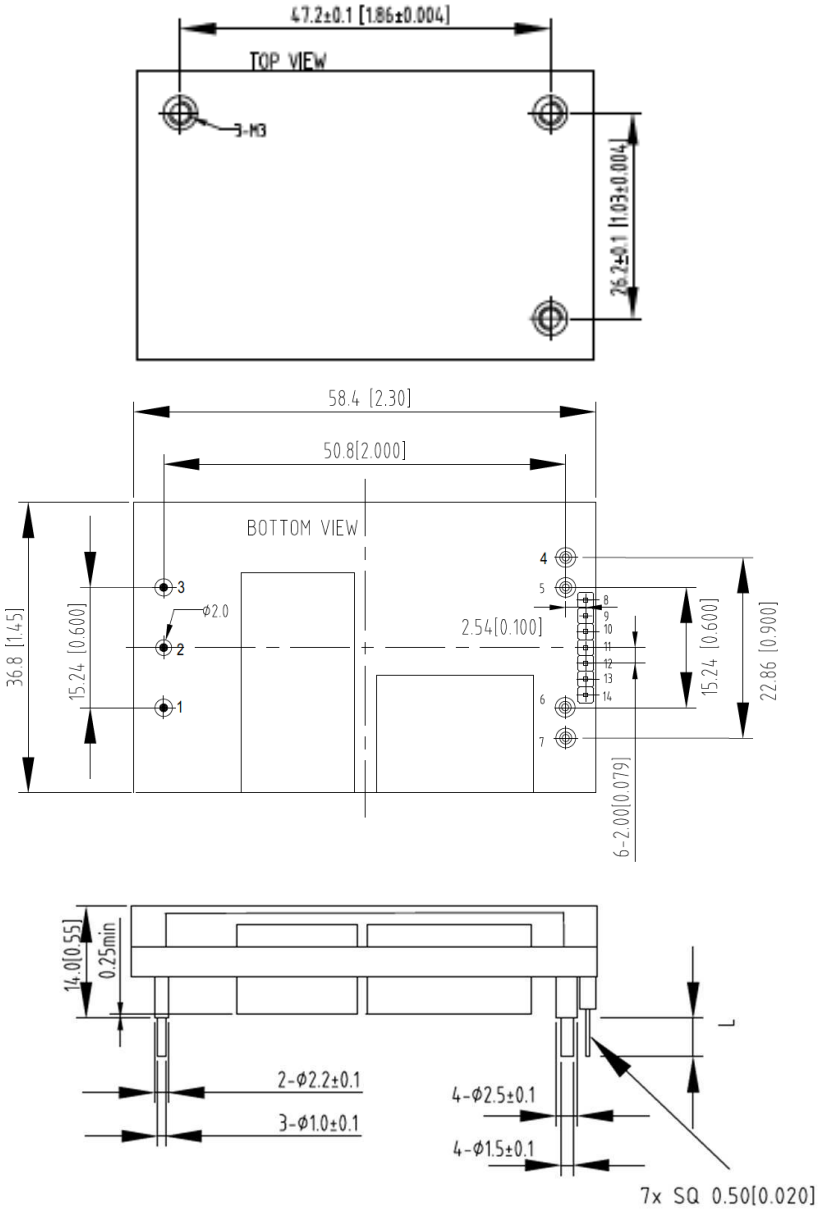


Figure 9: NDQ900-48S12B-6LI Power Loss @ 25°C, 800 LFM
Vin = 40 to 60 Vdc
Loading: Io = 10% increment to 73.7 A

MECHANICAL SPECIFICATIONS

Mechanical Outlines



UNIT: mm (inch) L=3.80 mm
TOLERANCE: X.X mm±0.5 mm (X.XX in.± 0.02 inch)
X.XX mm±0.25 mm (X.XXX in.±0.01 inch)

Note 1 - Dimensions within the box are critical dimensions.
Note 2 - NDQ900-48S12B-6LI has pin 8 to 14,
Note 3 - The minimum clearance from customer PCB is 0.2 mm (0.008 inch).
Note 4 - Depth penetration into base plate, of M3 screws used at baseplate mounting holes, not to exceed maximum of 3.0 mm.

MECHANICAL SPECIFICATIONS

Pin Length option

Device code suffix	L
-4	4.6 mm±0.25 mm
-6	3.8 mm±0.25 mm
-8	2.8 mm±0.25 mm
None	5.8 mm±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-	NA	Yes
5	Vo-	Negative output voltage	
6	Vo+	Positive output voltage	
7	Vo+	NA	Yes
8	PG	Power Good	Yes
9	Sig_gnd	PMBus Interface	Yes
10	Data	PMBus Interface	Yes
11	SMBAlert	PMBus Interface	Yes
12	Clock	PMBus Interface	Yes
13	Addr	PMBus Interface	Yes
14	Ishare	Current Share	Yes

ENVIRONMENTAL SPECIFICATIONS

Input Fusing

The internal fuse is fast blow type. An external fuse is recommended. To meet international safety requirements, recommended rating is 50 A /150 Vdc for the converter.

EMC Immunity

NDQ900-48S12B series power supply is designed to meet the following EMC immunity specifications:

Table 4. Environmental Specifications

Document	Description	Criteria
EN55032, DC input port, Class A	Conducted EMI Limits, DC input port	/
IEC/EN 61000-4-2, Enclosure Port, Level 3	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Electrostatic discharge immunity test	B
IEC/EN 61000-4-4, Level 3	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Electrical Fast Transient. DC input port	B
IEC/EN 61000-4-6, Level 2	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Continuous Conducted Interference. DC input port	A
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.

Safety Certifications

The NDQ900-48S12B series 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 5. Safety Certifications for NDQ900-48S12B Series Power Supply System

Standard	Agency	Description
UL/CSA62368-1	UL+CUL	US and Canada Requirements
EN62368-1	TUV-SUD	European Requirements
IEC62368-1	IEC	International Requirements
CE	CE	CE Marking
UL94	UL	Materials meet V-0 flammability rating
UKCA		UK Requirements

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature

The NDQ900-48S12B series power supply will start and operate within stated specifications at an ambient temperature from -40°C to 85°C under all load conditions. The storage temperature is -55°C to 125°C.

Thermal Considerations - Baseplate module

NDQ900-48S12B 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 10. The temperature at these test points should not exceed the maximum values in Table 6.

For a typical application, Figure 11 shows the derating of output current vs. ambient air temperature at different air velocity@54V input with a 0.6" heat sink.

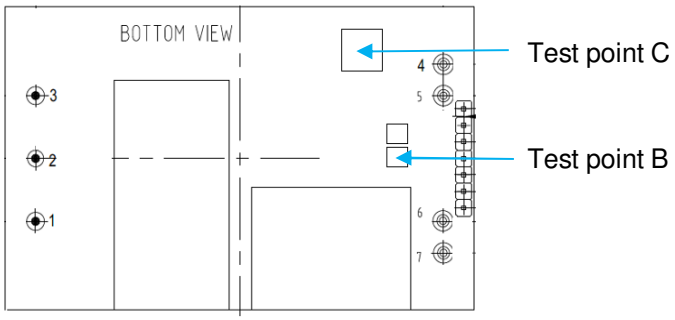


Figure 10 Temperature test points

Table 6. Temperature Limit of the Test Points	
Test Point	**Temperature Limit (°C)**
Test point A (Baseplate middle)	106
Test point B	120
Test point C	110

ENVIRONMENTAL SPECIFICATIONS

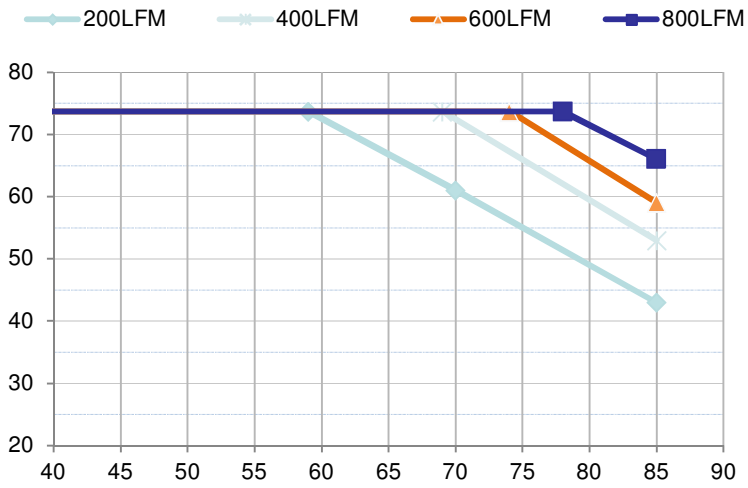


Figure 11 NDQ900-48S12B-6LI with 0.6" heat sink, output power derating at 54Vin, air flowing across the converter from Vin- to Vin+

Qualification Testing

Table 7. 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 to 100% load Vibration limit: > 25 G
Vibration	2	Frequency range: 5 Hz to 20 Hz, 20 Hz to 200 Hz, A.S.D: 1.0 m2/s3, -3 db/oct Axes of vibration: X/Y/Z. Time: 30 min/axis. Non-operational.
Mechanical Shock	2	Type: half sine, Acceleration: 30 g, Duration: 6 ms, Directions: 6 Number of shock: 3 times/face. Non-operational.
Thermal Shock	3	-55°C to 125°C, Temp dwell time: 30 min, Temp change rate: 20°C/min, Unit temperature 20 cycles
Thermal Cycling	3	-40°C to 85°C, temperature change rate: 1°C/min, cycles: 2 cycles
Humidity	3	40°C, 95%RH, 48 h
MTBF		Telcordia, SR332 Method 1 Case 1, 1.5 MHrs typically

APPLICATION NOTES

Typical Application

Below is the typical application of the NDQ900-48S12B series power supply.

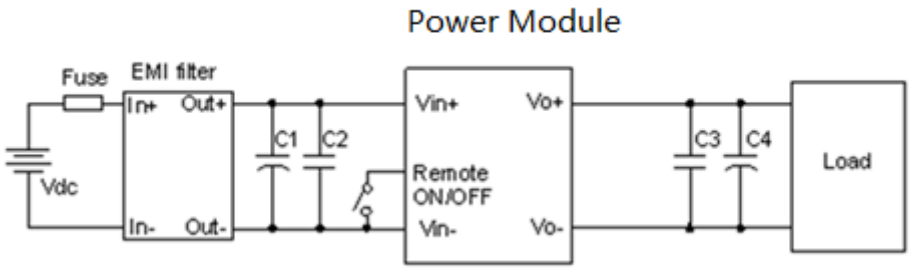


Figure 12 Typical application

C1: 300μF/100V electrolytic capacitor（2*47uF/80V OSCON cap+2*100uF/100V Nichicon cap）

C2: 0.1μF/100V X7R ceramic capacitor

C3: 1PCS 1μF/16V/X7S capacitor

C4: 4000μF/16V electrolytic capacitor, OSCON or POSCAP

Fuse: External fast blow fuse with a rating of 50A/150Vdc. The recommended fuse model is WM55-50 from Walter Electronic.

APPLICATION NOTES

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

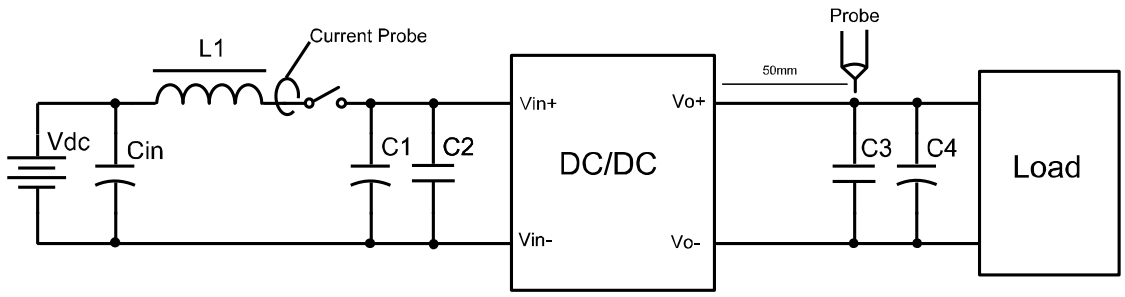


Figure 13 Input ripple & inrush current & output ripple and noise test configuration

Vdc: DC power supply

L1: 12µH

Cin: 300µF/100V typical

C1 to C4: See Figure 12

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

Power Good Function

The NDQ900-48S12B series has a power good function, the Power Good pin is open drain need external pull-up to high level.

When the unit is operating correctly, supplying power and all parameters are within specification, a logic-Low voltage will be present on this pin.

When the unit is NOT operating correctly - either is under a mode of protection (over temperature, overcurrent or overvoltage) that is causing the unit to “shut-down” and not supply power, or, if the unit has failed, there will be logic-High voltage present on this pin. The high level will not exceed 5V.

APPLICATION NOTES

EMC test conditions

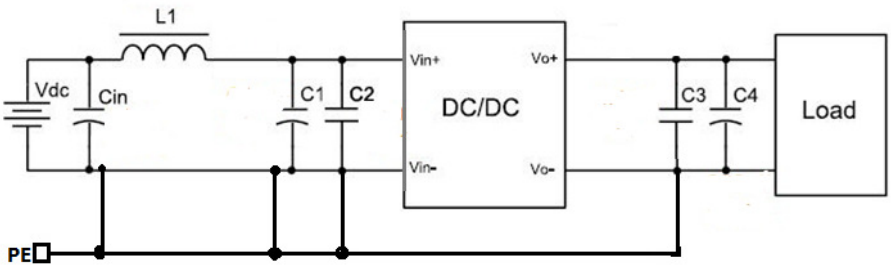


Figure 14 EMC test conditions

Cin: 2*10uF/100V/X7R + 4*4.7uF/100V/X7R ceramic capacitor

C1: 241μF/100V electrolytic capacitor (2*47uF/80V OSCON cap+147uF/100V Nichicon cap)

C2: 2*2.2uF/100V/X7R + 1uF/100V/X7R ceramic capacitor

C3: 10*22uF/16V/X7R ceramic capacitor

C4: 4000μF/16V electrolytic capacitor, OSCON

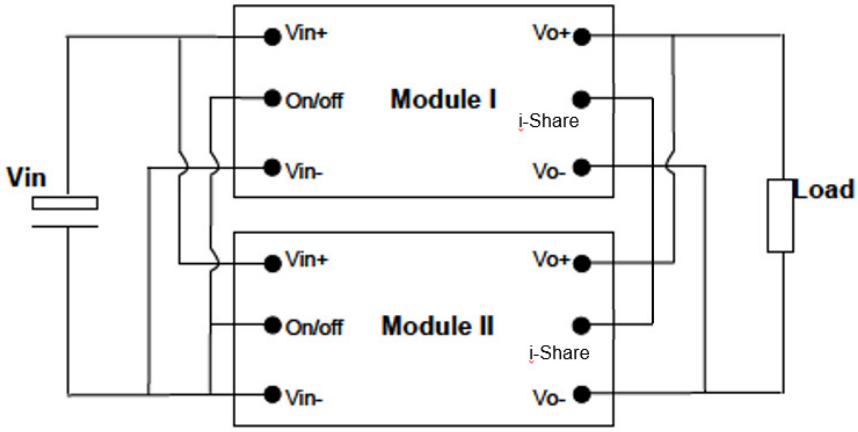
L1: 5.1uH inductor

Fuse: External fast blow fuse with a rating of 50A /150Vdc. The recommended fuse model is WM55-50 from Walter Electronic.

APPLICATION NOTES

Current Share Function

The modules are capable of operating in parallel and realizing current sharing by active current sharing method. There is a current sharing pin. By connecting the Vin pin the Vo pin and the Ishare pin of the parallel module together, the current sharing can be realized automatically. Max parallel module number is 2 (parallel maximum load ≤ 118 A).



If system has no redundancy requirement, the module can be parallel directly for higher power without adding external ORing-FET; whereas, if the redundancy function is required, the external ORing-FET should be added.

For a normal parallel operation, the following precautions must be observed:

- The current sharing accuracy equation is:

  X% = | Io - (Itotal / N) | / Irated, Where:

  Io is the output current of per module;

  Itotal is the total load current;

  N is parallel module numbers;

  Irated is the rated full load current of per module.

- To ensure a better steady current sharing accuracy, below design guideline should be followed:

a) The inputs of the converters must be connected to the same voltage source, and the PCB trace resistance from input voltage source to Vin+ and Vin- of each converter should be equalized as much as possible.

b) The PCB trace resistance from each converter's output to the load should be equalized as much as possible.

c) For accurate current sharing accuracy test, the module should be soldered in order to avoid the unbalance of the touch resistance between the modules to the test board.

- To ensure the parallel module can start up monotonically without trigging the OCP circuit, below design guideline should be followed:

a) Before all the parallel module finished start up, the total load current should be lower than the 50% rated current of one module.

b) The ON/OFF pin of the converters should be connected together to keep the parallel modules start up at the same time.

c) The undervoltage lockout point will slightly vary from unit to unit. The dv/dt of the rising edge of the input source voltage must be greater than 1 V/ms to ensure that the parallel module start up at the same time.

SOLDERING INFORMATION

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 7 s.

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

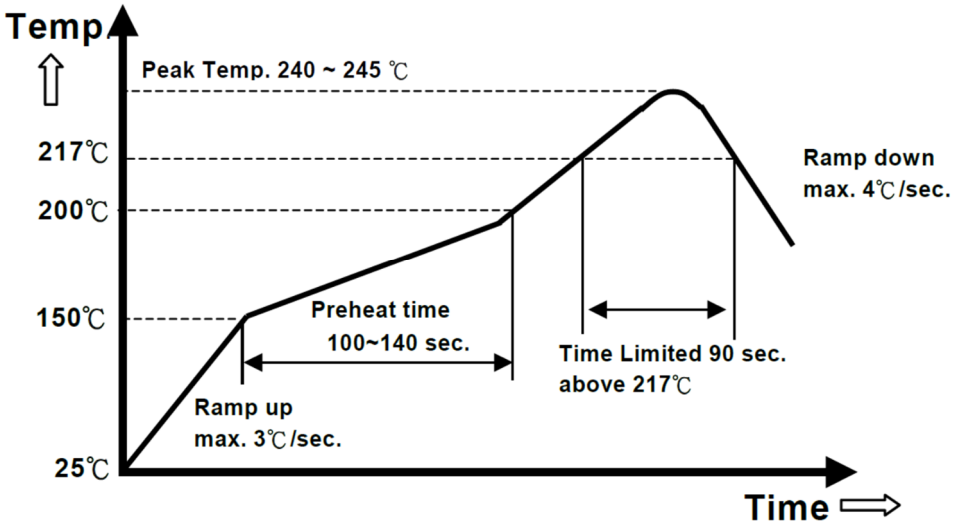
Cleaning of solder joint can be performed with cleaning solvent IPA or simulative.

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 217^{O}C should be less than 90 s.

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™ SPECIFICATIONS

PMBus™ General Instructions

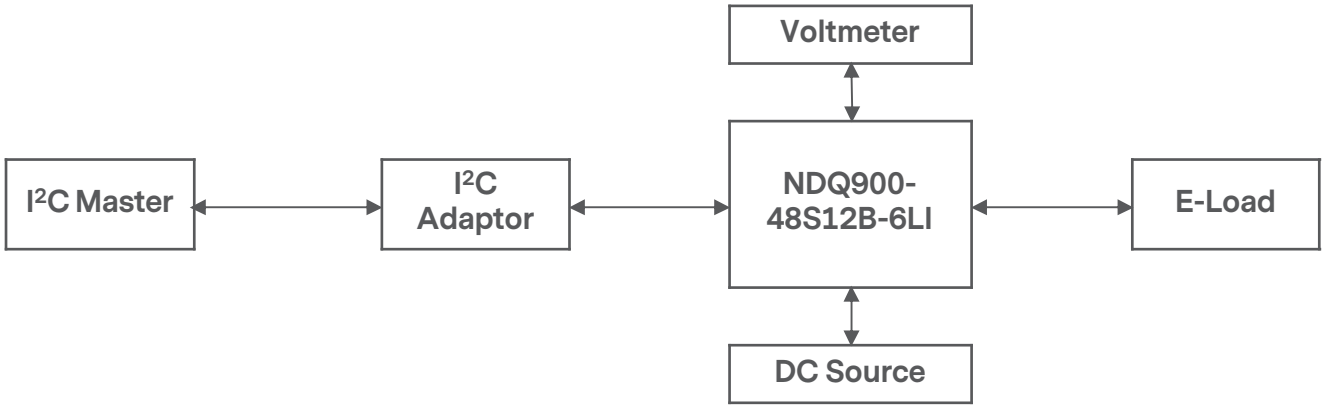
The NDQ900-48S12B-6LI is compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the I²C interface port. Detailed timing and electrical characteristics of the PMBus™ can be found in the PMB Power Management Protocol Specification, Part 1, revision 1.2, available at http://PMBus.org.

The module supports 100 kHz bus timing requirements. The module shall stretch the clock, as long as it does not exceed the maximum clock LO period of 35 ms. It is recommended to always use PEC (Packet Error Check) when communicating via PMBus.

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.

Equipment Setup

The following is typical I²C communication setup:



PMBus™ Signal Interface Characteristics

Table 8. PMBus™ Signal Interface Characteristics[1]

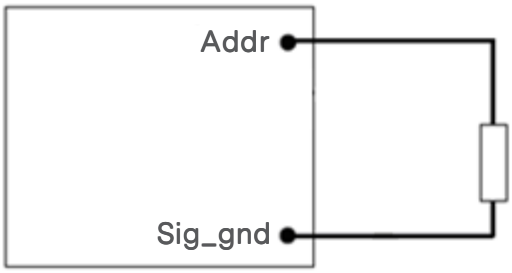
Parameter	Conditions	Min	Typ	Max	Unit
Input High Voltage (Clock, Data, Ishare)		2.1	-	3.6	V
Input Low Voltage (Clock, Data, PG, Ishare)		0	-	0.8	V
Input High Level Current (Clock, Data, PG)		-2.5	-	2.5	mA
Output Low Voltage (SMBAlert, Clock, Data)	I_O = 2mA	-	-	0.4	V
PMBus Operation Frequency[2]		100			kHz

Note 1 - The max current of Sig_gnd pin is 0.4A.
Note 2 - For applications where PMBus frequency at 400 kHz is required, please contact Advanced Energy technical support.

PMBus™ SPECIFICATIONS

PMBus™ Addressing

The module has flexible PMBus™ addressing capability. By connecting different resistors from Addr pin to Sig_gnd pin, 15 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 126 will be returned.



Resistor (kOhm)	7-bit Address	8-bit Address
0	96	0xC0h
10	96	0xC0h
15	97	0xC2h
21	98	0xC4h
28	99	0xC6h
35.7	100	0xC8h
45.3	101	0xCAh
56.2	102	0xCCh
69.8	103	0xCEh
88.7	104	0xD0h
107	105	0xD2h
130	106	0xD4h
158	107	0xD6h
191	108	0xD8h
232	109	0xDAh
Open	127	0xFEh

PMBus™ SPECIFICATIONS

PMBus™ Adjustable Input Undervoltage Lockout

The module allows adjustment of the input undervoltage 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 40.000 V in 0.125 V steps. VIN_ON must be 1.5 V 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.

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 10 ms and 200 ms, with resolution of 0.5 ms. The TON_RISE command sets the rise time in ms, and allows choosing soft start times between 20 ms and 50 ms, with resolution of 0.5 ms. 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 overcurrent 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 resolution is 0.244 mV . The data associated with VOUT_COMMAND can be stored to non-volatile memory using the STORE_DEFAULT_ALL command.

Range limits (max/min): 13.2/10.8 V

Notes:

- Trim up @ Vin = 44 to 60 V,
- When trimmed up, the output power not to exceed 900 W;
- When operated in parallel operation, it is not recommend to use trim function.

  (If trim function is intended for use when two units are in sharing connection, please contact Advanced Energy Technical support for guidance).

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.

PMBus™ SPECIFICATIONS

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.

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 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.

Black Box

There is a black box function realized by 22 pages of D-flash (20 K erase cycles up to 120^{O}C hotspot temp). The first page is used to save the page number where the newest history event is recorded. A further 21 pages with 19 byte per page, are assigned to record 21 history events. The fault time is also recorded. The fault time is the time from the last Vo turn on until the time of the fault occurs. The following fault events can trigger recording of history event data to the black box: Vin UVP, Vin OVP, Vout OVP, Vout OCP, and OTP.

Note: An input UVP event may not be recorded during high slew rate loss of input.

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:

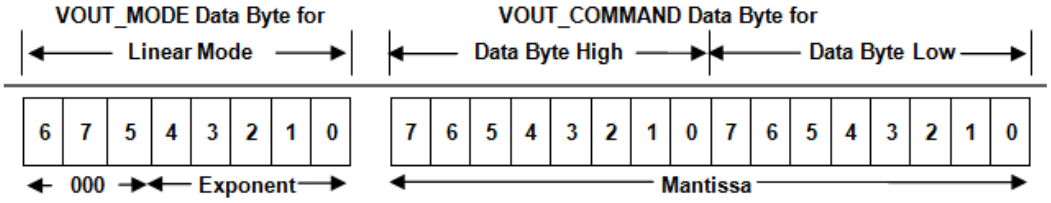
0 : Output is disabled

1 : Output is enabled

PMBus™ SPECIFICATIONS

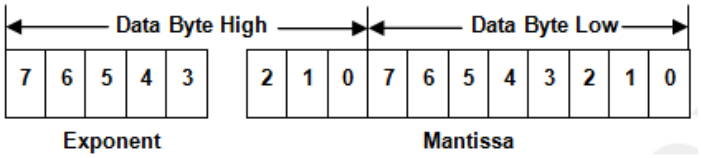
PMBus™ Data Format

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 $2^{Exponent}$

Measurement System Characteristics

Table 9. Measurement System Characteristics

Parameter	Conditions	Min	Typ	Max	Unit
Output current reading accuracy[1]	I_O = 60% to 100% $I_{O,max}$	-8	-	8	%
	I_O = 0% to 60% $I_{O,max}$	-4.5	-	4.5	A
Output current reading resolution[1]		-	0.25	-	A
Vo reading accuracy[1]		-2	1	2	%
Vo reading resolution[1]		-	0.25	-	V
Vin reading accuracy[1]		-4	-	4	%
Vin reading resolution[1]		-	0.125	-	V
Temperature reading accuracy	T_A > 0°C	-	3	-	°C
Temperature reading resolution	T_A > 0°C	-	1	-	°C

Note 1 – Current reading accuracy and resolution at typical Vonom when the temperature above zero.

PMBus™ SPECIFICATIONS

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	Power Good (Negative logic)	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 Overvoltage	0
4	IOUT Overcurrent	0
3	VIN Undervoltage	0
2	Temperature	0
1	CML (Command)	0
0	X	0

PMBus™ SPECIFICATIONS

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 overvoltage 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 overvoltage warning	0
5	Input undervoltage warning	0
4	VIN UV Fault	0
3	X	0
2	X	0
1	X	0
0	X	0

PMBus™ SPECIFICATIONS

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:

- The device receives a CLEAR_FAULTS command
- Bias power is removed from the module

PMBus™ SPECIFICATIONS

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.

OPERATION [0x01]

Command support: On/Off Immediate

Bit Position	Purpose	Bit Value	Meaning
7	Enable/Disable the module	1	Output is enabled
		0	Output is disabled
6	Reserved		
5:4	Vout Command	00	No margin
3:0	Reserved		

CLEAR_FAULTS [0x03]

Command support: All functionality

WRITE PROTECTION [0x10]

Command support: Supported. Factory default: 0x10 - Indicates protection is enabled.

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

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.

PMBus™ SPECIFICATIONS

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

VOUT_COMMAND [0x21]

Data format: 16 bit unsigned mantissa (implied exponent per VOUT_MODE)

Factory default: 12.25 V

Range limits (max/min): 13.2/10.8 V

Unit: volt

Notes:

- Trim up within the input voltage range: Vin = 44 to 60 V.
- When trimming up, make sure the output power does not exceed 900 W.
- When operating in parallel operation, it is not to recommend to use trim function.

(If trim function is intended for use when two units are in current sharing connection, please contact Advanced Energy Technical support for guidance).

VIN_ON [0x35]

Range limits (max/min): 40/35

Unit: volt

Command support: All functionality

Note: Special interlock checks between VIN_ON and VIN_OFF maintain a hysteresis gap of 1.5 V minimum and do not allow the OFF level to be higher than and ON level.

VIN_OFF [0x36]

Range limits (max/min): 39/34

Unit: volt

Command support: All functionality

Note: Special interlock checks between VIN_ON and VIN_OFF maintain a hysteresis gap of 1.5 V minimum and do not allow the OFF level to be higher than and ON level.

VOUT_OV_WARNING_LIMIT [0x42]

Range limits (max/min): 15/13.5

Unit: volt

Command support: All functionality

Note: Value must be the same or less than VOUT_OV_FAULT_LIMIT value.

PMBus™ SPECIFICATIONS

VOUT_OV_FAULT_LIMIT [0x40]

Range limits (max/min): 15/13.5

Unit: volt

Command support: All functionality

Note: Range cross-check-value must be greater than VOUT_COMMAND value.

IOUT_OC_FAULT_LIMIT [0x46]

Range limits (max/min): 110/80

Unit: 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): 110/78

Unit: amp

Command support: Read/write support, functionality complete

Note: Range cross-check-value must be the same or less than IOUT_OC_FAULT_LIMIT value.

OT_FAULT_LIMIT [0x4F]

Range limits (max/min): 127/25

Unit: degC

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

Unit: degC

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): 66/61

Unit: volt

Command support: All functionality

PMBus™ SPECIFICATIONS

STATUS_WORD [0x79]

Command support: full implementation for supported functions, all bit reset supported

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 and VOUT_OV_WARN 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	VOUT_OV _FAULT	VOUT_OV _WARN	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved

STATUS_IOUT [0x7B]

Command support: IOUT_OC_FAULT and IOUT_OC_WARN 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	IOUT_OC _FAULT	Reserved	IOUT_OC _WARN	Reserved	Reserved	Reserved	Reserved	Reserved

STATUS_INPUT [0x7C]

Command support: VIN_OV_FAULT, VIN_OV_WARN, VIN_UV_WARN and VIN_UV_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	VIN_OV_ FAULT	VIN_OV_ WARN	VIN_UV_ WARN	VIN_UV_ FAULT	Reserved	Reserved	Reserved	Reserved

PMBus™ SPECIFICATIONS

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]

Command support: Invalid/Unsupported Command Received, Invalid/Unsupported Data Received and Packet Error Check Failed 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	Invalid/Unsupported Command Received	Invalid/Unsupported Data Received	Packet Error Check Failed	Reserve	Reserved	Reserved	Reserved	Reserved

READ_VIN [0x88]

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

PMBus™ SPECIFICATIONS

CLEAR BLACKBOX [0XB6]

Command support: write support

Write 0xAA to the command, blackbox can be cleared and all history event data is set to 0.

BLACKBOX_EN [0xDF]

The black box can be set to stop recording once full (21 fault events recorded) or to overwrite the oldest fault event data with the next fault event data once full. The module is shipped with a default setting of overwrite enabled.

Bit Position	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 21 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 start overwriting previous faults, starting from entry 0.

PMBus™ SPECIFICATIONS

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.

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]

Reading 0xE1 yields the value x of the next history event (to be recorded in the future). To read the last history event (the most recent history event recorded), send write command 0XE1 with offset value of x-1. Then send read command 0XE0 and the last event data will be read back. There are 21 possible values for the offset (0-20), if the number of history events is larger than 20, 0XE1 will be reset 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_byte	Fault time_fourth_byte	PEC	Stop

Fault timer: Record the operating time since last fault, up to 256 days. Fault time_first_byte is seconds; Fault time_second_byte is minutes; Fault time_third_byte is hours; Fault time_fourth_byte is days. If no fault occurs after 256 days of operating time the counter will reset and begin a new count.

PMBus™ SPECIFICATIONS

NDQ900-48S12B-6LI Supported PMBus™ Command list

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
01h	OPERATION	80h	R/W	1	Bit field	Used to turn the unit ON/OFF
02h	ON_OFF_CONFIG	1Dh	R/W	1	Bit field	0x1Dh(Neg Logic); 0x1Fh(Pos Logic)
03h	CLEAR_FAULTS	-	Send	1	N/A	Clear any fault bits that have been set
10h	WRITE_PROTECTION	10h	R/W	1	Bit field	Set or Clear the bit of Write protection
11h	STORE_DEFAULT_ALL	-	Send	0	N/A	Stores operating parameters to E^2prom memory
12h	RESTORE_DEFAULT_ALL	-	Send	0	N/A	Restores operating parameters from E^2prom memory
19h	CAPABILITY	B0h	R	1	Bit field	Information of a PMBus device
20h	VOUT_MODE	14h	R	1	Mode+exp	To read VOUT data format
21h	VOUT_COMMAND	-	R/W	2	VOUT linear	Set the output voltage
33h	FREQUENCY_SWITCH	-	R	2	Linear, Exponent is 0	Read the switching frequency
35h	VIN_ON	-	R/W	2	Linear	Set the turn on voltage threshold of vin
36h	VIN_OFF	-	R/W	2	Linear	Set the turn off voltage threshold of vin
40h	VOUT_OV_FAULT_LIMIT	-	R/W	2	VOUT linear	Set the output overvoltage fault threshold
42h	VOUT_OV_WARN_LIMIT	-	R/W	2	VOUT linear	Set the output overvoltage warn threshold
46h	IOUT_OC_FAULT_LIMIT	-	R/W	2	Linear	Set the output overcurrent fault threshold
4Ah	IOUT_OC_WARN_LIMIT	-	R/W	2	Linear	Set the output overcurrent warn threshold
4Fh	OT_FAULT_LIMIT	-	R/W	2	Linear	Set the over temperature fault threshold
51h	OT_WARN_LIMIT	-	R/W	2	Linear	Set the over temperature warn threshold
55h	VIN_OV_FAULT_LIMIT	-	R/W	2	Linear	Set the input overvoltage fault threshold
5Eh	POWER_GOOD_ON	9000h	R/W	2	VOUT linear	Set POWER GOOD on flip level
5Fh	POWER_GOOD_OFF	8000h	R/W	2	VOUT linear	Set POWER GOOD off flip level
60h	TON_DELAY	-	R/W	2	Linear	Set the power on delay time
61h	TON_RISE	-	R/W	2	Linear	Set the power on rise time
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 overvoltage and undervoltage 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

PMBus™ SPECIFICATIONS

NDQ900-48S12B-6LI Supported PMBus™ Command list

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
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	Variable	Char	Artesyn
9Ah	PMBus_CMD_MFR_MODEL	-	R	Variable	Char	Returns the name of the module
9Bh	MFR_FW_REV	-	R	Variable	Char	Returns the version of the software
9Ch	MFR_MOD_DATE_LOC_SN	-	R/W	Variable	Char	Returns the production's place of the module
9Eh	PMBus_CMD_MFR_SERIAL	-	R/W	Variable	Char	Returns the serial number of the module
B6h	CLEAR BLACKBOX	-	W	1	N/A	Clear blackbox, set all history event data to 0
DFh	BLACKBOX_EN	01h	R/W	1	Bit field	Enable or disable the blackbox overwrite function
E0h	READ_HISTORY EVENTS	-	R	Variable	NA	Max 20 events, 20 commands
E1h	SET_HISTORY_EVENT _OFFSET	-	R/W	1	NA	Max 20 events, 20 commands

RECORD OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	10.21.2022	First Issue	E. 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.

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