GDQ33S12B/P
DC-DC Converter Technical Manual V1.7

Quarter-Brick DC-DC Converter	36 - 72 V Input	12 V Output	33 A Current	Negative Logic

Description

The GDQ33S12B/P is an isolated DC-DC converter that uses an industry nonstandard quarter-brick structure and features high efficiency and power density. It provides 12 V outputs and supports the maximum output current of 33 A. Two GDQ33S12B/Ps can be connected in parallel to provide the maximum output current of 54 A. The GDQ33S12B/P communicates over PMBus 1.1 to support monitoring and alarm reporting functions, such as monitoring the output voltage and current, input voltage, digitally adjusting the voltage, and activating software.

GDQ33S12B/P

Operational Features

- Input voltage: 36 - 72 V
- Output current: 0 - 33 A
- Rated output voltage: 12 V
- Efficiency: 96.0% (12 V, 16.5 A)

Mechanical Features

- Industry nonstandard quarter-brick (D x W x H, with a baseplate): 57.9 mm x 36.8 mm x 12.7 mm (2.28 in. x 1.45 in. x 0.50 in.)
- Weight: about 66 g

Protection Features

- Input undervoltage protection
- Output overcurrent protection (hiccup mode)
- Output short circuit protection (hiccup mode)
- Output overvoltage protection (hiccup mode)
- Overtemperature protection (self-recovery)

Key Features

- PMBus Revision 1.1 compliant

Monitoring Features

- Activates hardware and software
- Digitally adjusts the voltage
- Monitors the input and output voltages
- Monitors the output current

Safety Features

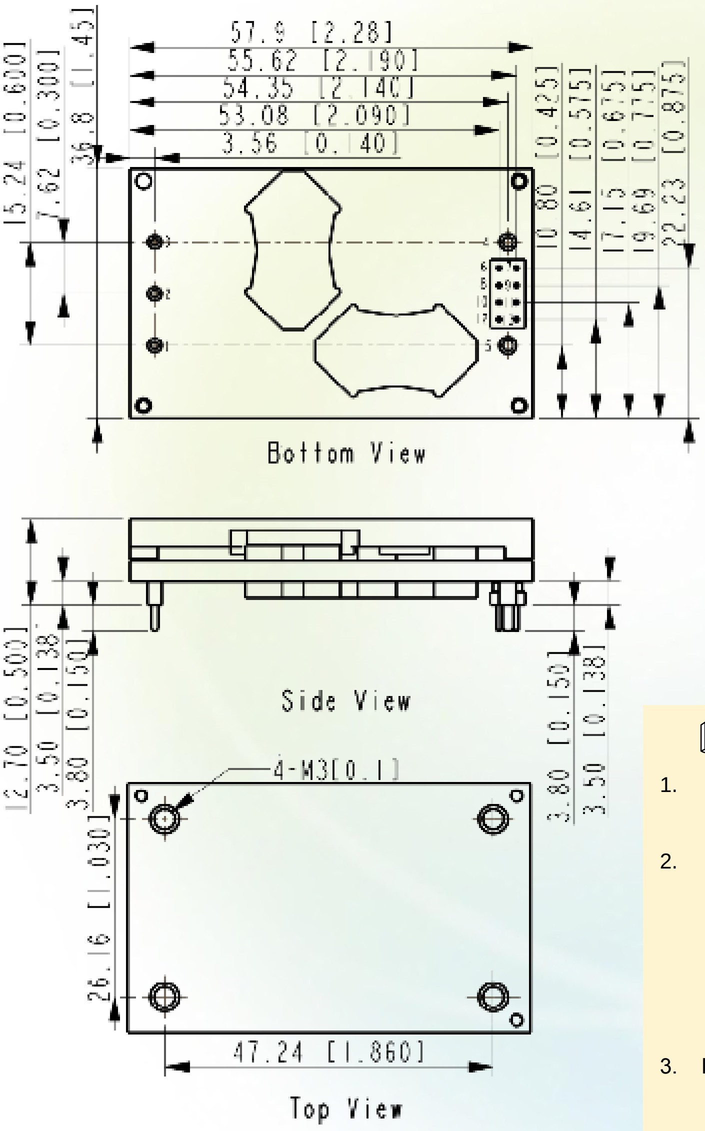
- UL60950-1 and CSA C22.2 No. 60950-1-07
- Meet UL94V-0 flammability requirements
- RoHS6 compliant

Designation Explanation

GDQ	33	S	12	B	/P
1	2	3	4	5	6

1 — 48Vin, high performance, digital control quarter-brick
2 — Output current: 33 A
3 — Single output
4 — Output voltage: 12 V
5 — With a baseplate
6 — With a PMBus port

Mechanical Diagram



Pin Description

Pin No.	Function
1	V_{in} (+)
2	On/Off
3	V_{in} (–)
4	V_{out} (–)
5	V_{out} (+)
6	SGND
7	SA0
8	PMBus_ALT
9	SA1
10	PMBus_CTL
11	ISHARE
12	PMBus_SCL
13	PMBus_SDA

NOTE

1. All dimensions in mm [in.]
   Tolerances: x.x ± 0.5 mm [x.xx ± 0.02 in.]
   x.xx± 0.25 mm [x.xxx ± 0.010 in.]
2. Pin 1-3 are 1.00 ± 0.05 mm [0.040 ± 0.002 in.] diameter with 2.00 ± 0.10 mm [0.080 ± 0.004 in.] diameter standoff shoulders.
   Pin4 and pin5 are 1.50 ± 0.05 mm [0.060 ± 0.002 in.] diameter with 2.50 ± 0.10 mm [0.098 ± 0.004 in.] diameter standoff shoulders.
   Pin6 and pin13 are 0.64 ± 0.05 mm [0.025 ± 0.002 in.] diameter.
3. M3 Screw used to bolt unit's baseplate to other surfaces (such as heatsink) must not exceed 3.00 mm [0.120 in.] depth below the surface of baseplate.

Electrical Specifications

Conditions: T_A = 25°C (77°F), Airflow = 1.5 m/s (300 LFM), V_{in} = 48 V, unless otherwise notes.

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
Absolute maximum ratings					
Input voltage Continuous Transient (100 ms)	 - -	 - -	 80 100	 V V	 - -
Operating ambient temperature	-40	-	85	ºC	See the thermal derating curve
Storage temperature	-55	-	125	ºC	-
Operating humidity	-	-	95	% RH	Non-condensing
Input characteristics					
Operating input voltage	36	48	72	V	-
Maximum input current	-	-	14	A	V_{in}= 36 - 72 V; I_{out} = 33 A
No-load loss	-	3	-	W	V_{in}= 48 V; I_{out} = 0 A
Input capacitance	100	220	-	µF	Electrolytic capacitor
Inrush transient	-	-	1	A^2s	-
Input reflected ripple current (peak to peak)	-	-	200	mA	Oscilloscope bandwidth: 20 MHz
Output characteristics					
Output voltage set point	11.88	12	12.12	V	V_{in} = 48 V; I_{out} = 16.5 A
Output power	0	-	396	W	-
Output line regulation	-	-	±0.20	%	V_{in}= 40 - 72 V; I_{out} = 33 A
	-	-	±10	%	V_{in}= 36 - 40 V; I_{out} = 33 A
Output load regulation	-	-	±3	%	V_{in} = 48 V; I_{out} = 0 - 33 A
Temperature coefficient	-	-	0.02	$\%V_{out}$ / °C	T_A = -40°C to +85°C (-40°F to +185°F)
Output voltage range	11.64	-	12.36	V	V_{in}= 40 - 72 V
	10.80	-	12.36	V	V_{in}= 36 - 40 V
External capacitance	470	660	10^4	µF	Electrolytic capacitor (10mΩ< ESR<1Ω)
Output current	0	-	33	A	-
Output ripple and noise (peak to peak)	-	200	250	mV	Oscilloscope bandwidth: 20 MHz
Unbalance of current equalization	-10		10	%	V_{in} ≥ 38 V; P≥ 300 W
Output voltage Trim range	8.4	-	12	V	Adjust the voltage by the PMBus

Electrical Specifications

Conditions: T_A = 25°C (77°F), Airflow = 1.5 m/s (300 LFM), V_{in} = 48 V, unless otherwise notes.

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
Output characteristics					
Output voltage overshoot	-	-	5	%	The whole range of V_{in} , I_{out} and T_A
Output voltage rise time	-	50	100	ms	0 - 100%V_{out}
Output voltage delay time	-	50	100	ms	V_{in} - 10%V_{out}
Switching frequency	-	140	-	kHz	-
Protection characteristics					
Input undervoltage protection Startup threshold Shutdown threshold Hysteresis	 31 30 1	 34.5 32.5 -	 35.5 35 4	 V V V	 - - -
Output overcurrent protection	36	-	42	A	Hiccup mode
Output short circuit protection	-	-	2	Arms	Hiccup mode
Output overvoltage protection	14	-	16	V	Hiccup mode
Overtemperature protection Threshold Hysteresis	 115 10	 125 15	 135 20	 °C °C	Self-recovery The values are obtained by measuring the temperature of the hottest power component on the top surface of the converter
Dynamic characteristics					
Overshoot amplitude Recovery time	- -	- -	600 300	mV μs	Current change rate: 0.1 A/μs; V_{in}= 40 - 72 V; load : 25% - 50% - 25%; 50% - 75% - 50%
Efficiency					
100% load	94.5	95.0	-	%	V_{in} = 48 V; I_{out} = 33 A; T_A=25°C (77°F)
50% load	95.5	96.0	-	%	V_{in} = 48 V; I_{out} = 16.5 A; T_A = 25°C (77°F)
20% load	-	94.0	-	%	V_{in} = 48 V; I_{out} = 6.6 A; T_A = 25°C (77°F)
Isolation characteristics					
Input-to-output Isolation voltage	-	-	1500	V DC	Functional Isolation
Reliability characteristics					
Mean time between failures (MTBF)	-	1.5	-	Million hours	Telcordia SR332; 80% load; Airflow = 1.5 m/s (300 LFM); T_A = 40°C (104°F)

Electrical Specifications

Conditions: T_A = 25°C (77°F), Airflow = 1.5 m/s (300 LFM), V_{in} = 48 V, unless otherwise notes.

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
Logic input and output pins in the communications port characteristics					
Logic input low level	-	-	0.8	V	-
Logic input high level	2.1	-	3.6	V	-
Logic output low level	-	-	0.25	V	I_{OL}= 6mA
Logic output high level	0.6	-	3.6	V	I_{OH}= -6mA
PMBus setting-up time	100	-	-	ns	For details about the values of t_{set} and t_{hold}, see "Definition of I2C/PMBus Setting-up Time and Holding Time"
PMBus holding time	0	-	-	ns	
Other characteristics					
Primary On/Off voltage Low level High level	 -0.7 2.8	 - -	 1.2 8	 V V	The low electric level is effective
Primary On/Off current Low level	 -	 -	 1	 mA	-
Secondary CTL voltage Low level High level	 0 2.1	 - -	 0.8 3.3	 V V	The high electric level is effective
Secondary CTL current Low level	 -	 -	 1	 mA	-
PMBus detected precision					
Input voltage detected precision	-1	-	1	V	V_{in}=36 - 72 V; Iout=0 - 33 A; T_A = -40°C to +85°C (-40°F to +185°F)
Output voltage detected precision	- 0.2	-	0.2	V	
Output current detected precision	-1	-	1	A	
Output power detected precision	-12.56	-	12.56	W	
Temperature detected precision	-5		5	℃	V_{in}=36 - 72 V; Iout=0 - 33 A; T_A = -40°C to +85°C (-40°F to +185°F)

Characteristic Curves

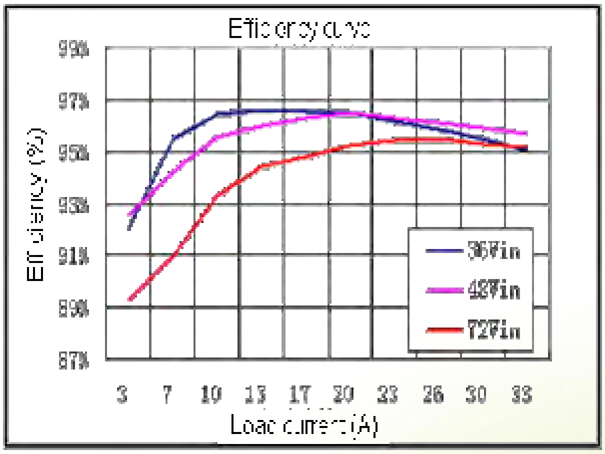


Figure 1: Efficiency (T_A = 25°C or 77°F)

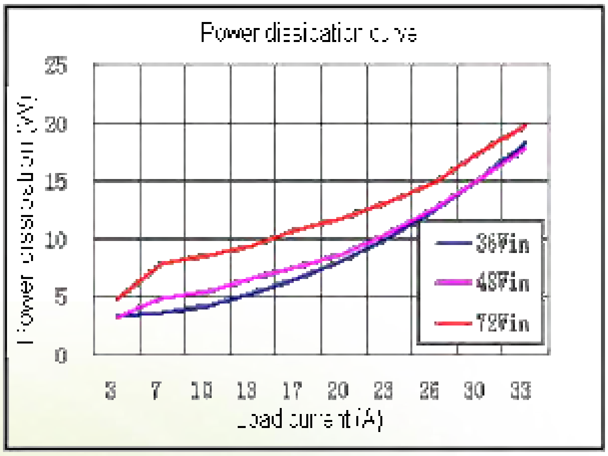


Figure 2: Power dissipation (T_A = 25°C or 77°F)

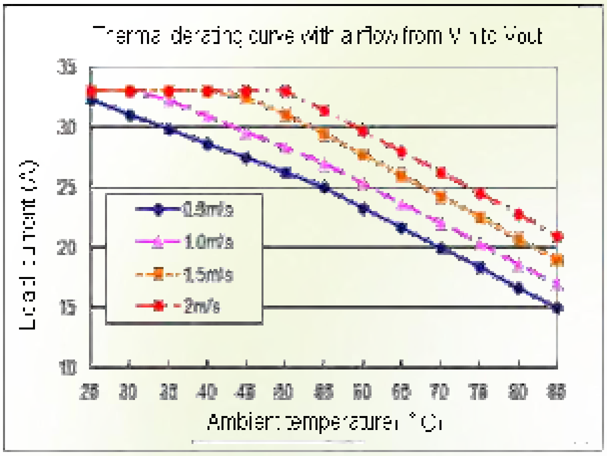


Figure 3: Thermal derating with airflow from V_{in} to V_{out} (V_{in} = 48 V; V_{out} = 12 V)

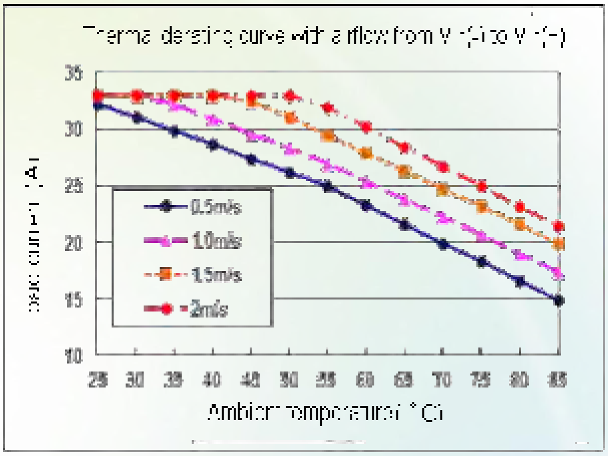


Figure 4: Thermal derating with airflow from V_{in}(-) to V_{in}(+) (V_{in} = 48 V; V_{out} = 12 V)

Typical Waveforms

NOTE

1. During the test of input reflected ripple current, the input terminal must be connected to a 12 μH inductor and a 220 μF electrolytic capacitor.
2. Point B, which is for testing the output voltage ripple, is 25 mm (0.98 in.) away from the V_{out}(+) pin.

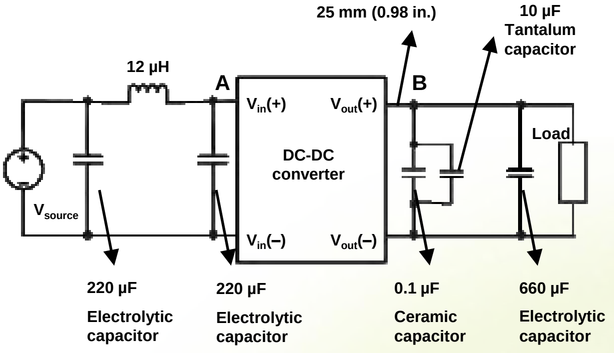


Figure 5: Test set-up diagram

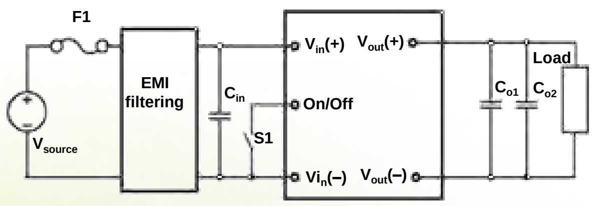


Figure 6: Typical circuit applications

F1: 20 A fuse (fast blowing)
C_{in}: The high-frequency, low equivalent series resistance (ESR) electrolytic capacitor (220 μF/100 V) is recommended.
C_{o1}: The 1 μF/25 V ceramic capacitor is recommended.
C_{o2}: The 660 μF tantalum capacitor is recommended.

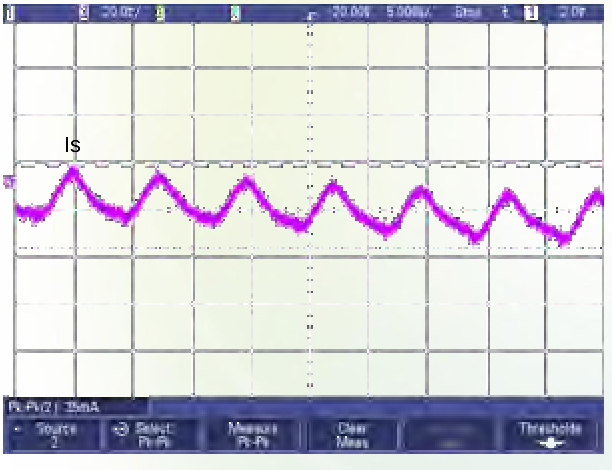


Figure 7: Input reflected ripple current
(for point A in the test set-up diagram, V_{in} = 48 V, V_{out} = 12 V, I_{out} = 33 A)

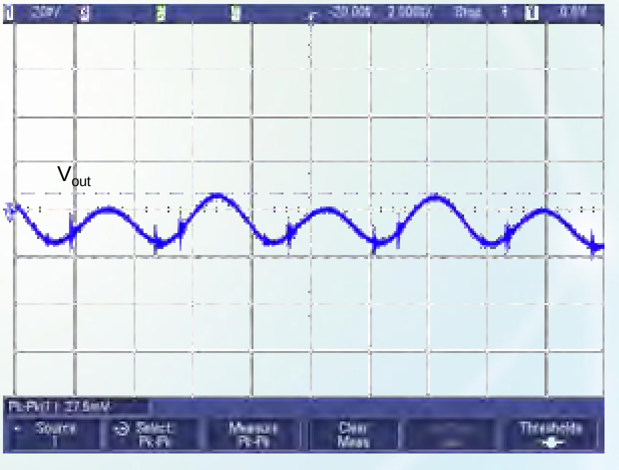


Figure 8: Output voltage ripple
(for point B in the test set-up diagram, V_{in} = 48 V, V_{out} = 12 V, I_{out} = 33 A)

Typical Waveforms

Conditions: T_A = 25°C (77°F), V_{in} = 48 V.

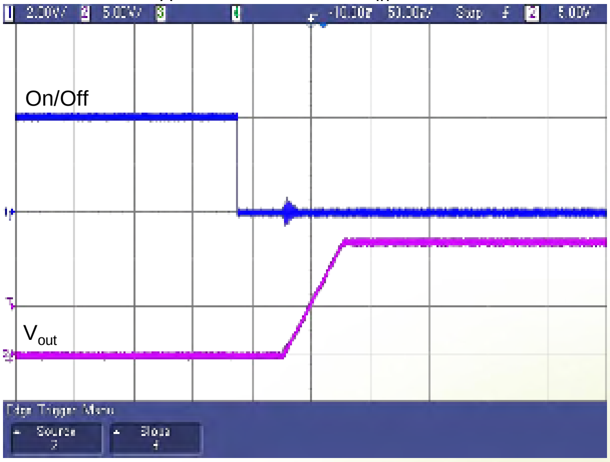


Figure 9: Startup from On/Off

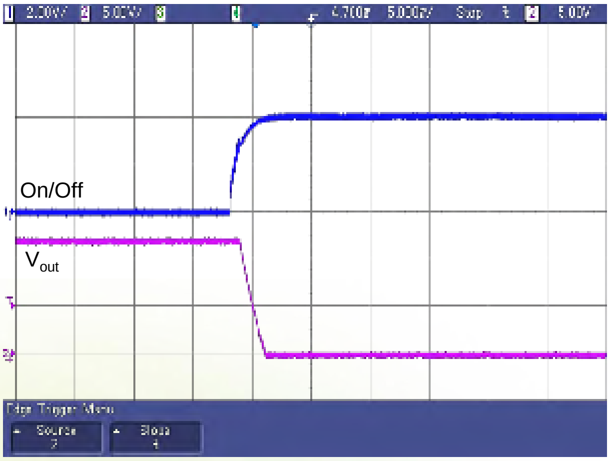


Figure 10: Shutdown from On/Off

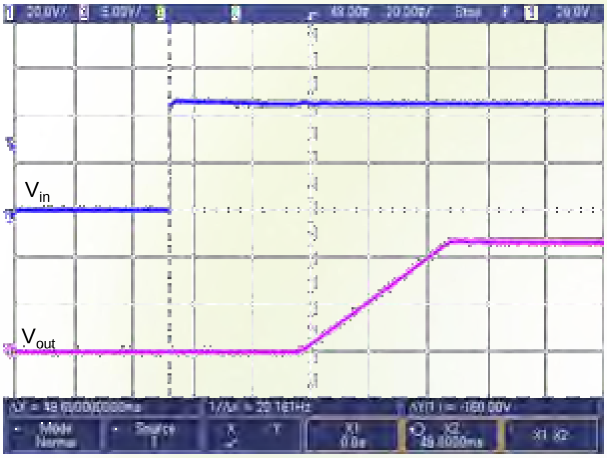


Figure 11: Startup by power on

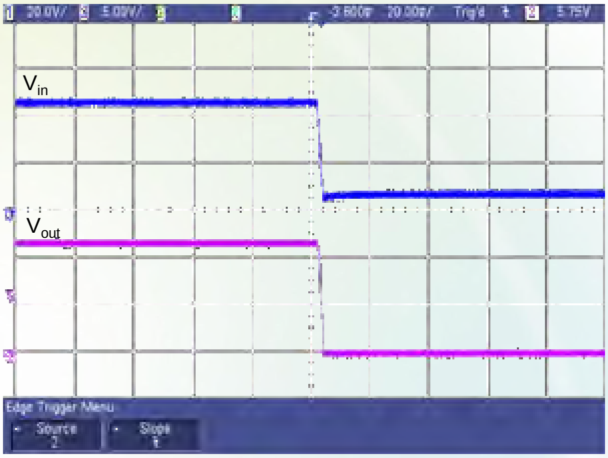


Figure 12: Shutdown by power off

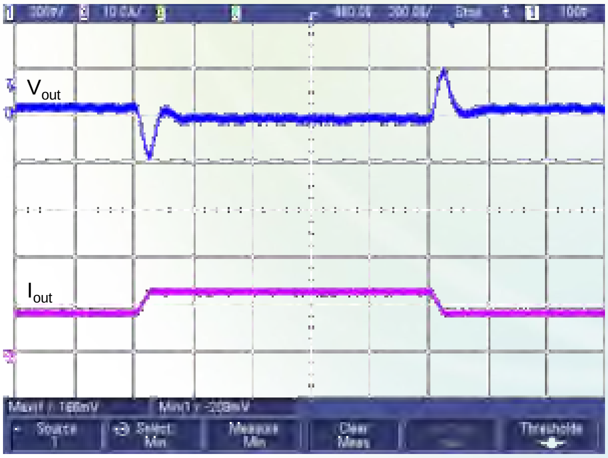


Figure 13: Output voltage dynamic response
(Load : 25% - 50% - 25%, di/dt=0.1 A/μs)

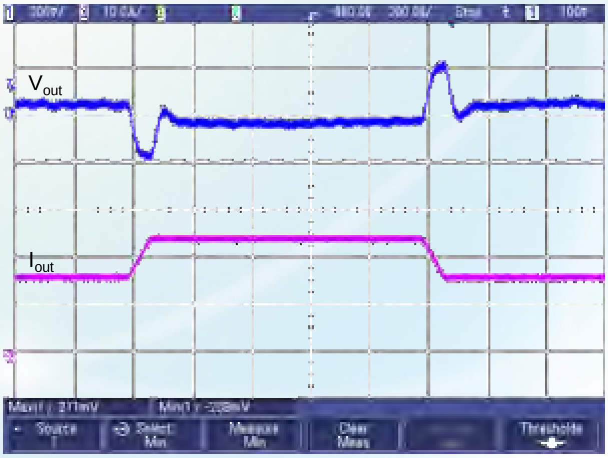


Figure 14: Output voltage dynamic response
(Load : 50% - 75% - 50%, di/dt=0.1 A/μs)

Remote On/Off

Logic Enable	On/Off Pin Level	Status
Negative logic	Low level	On
	High level or left open	Off

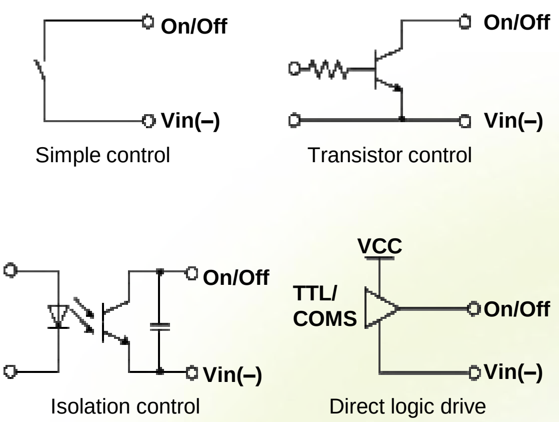


Figure 15: Various circuits for driving the On/Off pin

CTL Secondary Enable Control

When the On/Off is in low electric level, the PMBus_CTL can perform secondary enable control.

PMBus_CTL Pin Level	Status
Low level	No output
High level or left open	Have output

Output Voltage Adjust using PMBus

The converter supports online voltage adjustment by PMBus commands. The output voltage can be adjusted within the range of 8.4 V to 12.36 V.

Software Secondary Enable Control

See the PMBus communications protocol.

Soft-start Power Up

The default output voltage delay time (V_{in} - 10%V_{out}) is 50 ms. The default output voltage rise time (0 - V_{out}) is 50 ms. The softstart power up of the converter can be reconfigured using the PMBus commands.

Pre-Bias Start-up

The converter supports prebias. If the output terminal has a prebias voltage, the output voltage directly increases from the prebias voltage to the rated voltage after the converter starts. The following figure shows the typical waveform.

Figure 16: Pre-bias

Recommended Fuse

The converter has no internal fuse. To meet safety and regulatory requirements, a 20 A fuse is recommended.

NOTE

The fuse current should be 1.5 to 2 times the maximum operating current in actual use.

Recommend Reverse Polarity Protection Circuit

Reverse polarity protection is recommended under installation and cabling conditions where reverse polarity across the input may occur.

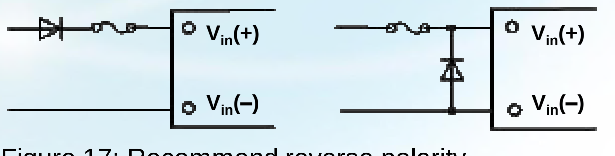


Figure 17: Recommend reverse polarity protection circuits

Input Undervoltage Protection

The converter will shut down after the input voltage drops below the undervoltage protection threshold for shutdown. The converter will start to work again after the input voltage reaches the input undervoltage protection threshold for startup. For the Hysteresis, see the Protection characteristics.

Output Overcurrent Protection

The converter equipped with current limiting circuitry can provide protection from an output overload or short circuit condition. If the output current exceeds the output overcurrent protection set point, the converter enters hiccup mode. When the fault condition is removed, the converter will automatically restart.

Output Overvoltage Protection

When the voltage directly across the output pins exceeds the output overvoltage protection threshold, the converter will enter hiccup mode. When the fault condition is removed, the converter will automatically restart.

Overtemperature Protection

A temperature sensor on the converter senses the average temperature of the module. It protects the converter from being damaged at high temperatures. When the temperature exceeds the overtemperature protection threshold, the output will shut down. It will allow the converter to turn on again when the temperature of the sensed location falls by the value of Overtemperature Protection Hysteresis.

MTBF

The MTBF is calculated according to the Telcordia, SR332 Method 1 Case3.

EMC

For the acceptance standard, see the *DC-DC Converter EMC Acceptance Manual.*

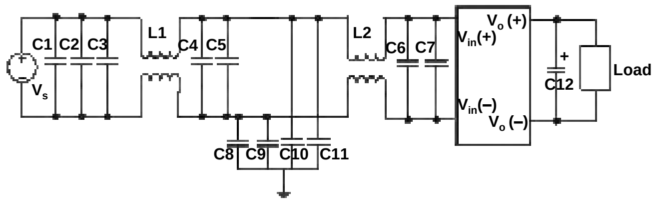


Figure 18: EMC test set-up diagram

C1, C2, C3, C4, C5: Surface mount device (SMD) ceramic capacitor (100 V/1000 nF/X7R/1210)

C6: SMD ceramic capacitor (100 V/100 nF/±10%/X7R/1206)

L1, L2: Common-mode inductor (single phase, 473 µH/±25%/14 A/ 1 mm x 25.4 mm x 12.7 mm [0.04 in. x 1.0 in. x 0.5 in.]). The chip component with the same specifications can also be used.

C8, C9, C10, C11: High-pressure resistant chip ceramic capacitor (100 nF/1000 V/X7R/2220). meeting the 1 kV pressure resistance requirement.

C7: Electrolytic capacitor (100 µF/100 V)

C12: Electrolytic capacitor (660 µF/25 V)

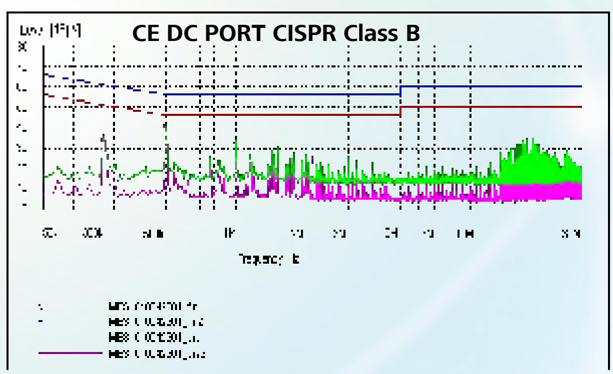


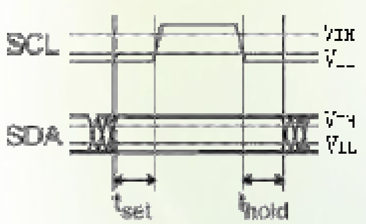
Figure 19: EMC test result

Pin Description

Pin	Description
On/Off	See "Remote On/Off"
PMBus_SCL and PMBus_SDA	PMBus communications port (connects to the I2C bus)
PMBus_CTL	See "CTL Secondary Enable Control"
SA1, SA0, and SGND	See "Address Definition"
ISHARE and PMBus_ALT	If only one converter is used, leave the two pins open. If two converters are connected parallel, connect ISHARE1 to ISHARE1 and PMBus_ALT to PMBus_ALT

Definition of I2C/PMBus Setting-up Time and Holding Time

t_{set} is the duration for which SDA keeps its value unchanged before SCL increases.
t_{hold} is the duration for which SDA keeps its value unchanged after SCL decreases.
The communication will fail if the time is not consistent with the specifications.



Parallel Operation

The products can be paralleled if external oring diodes or oring MOSFETS are used in series with the output.
For further information please contact your local sales representative.

NOTE

If two converters are connected in parallel, note the following:

1. Within 2 seconds after the converters start, the load current must not be less than or equal to 33 A.
2. The address of each converter is unique.

PCB Layout Consideration

Separate power trace and signal trace to avoid mutual interferance.

Address Definition

The resistances of R_{SA0} and R_{SA1} are different (resistors with 1% tolerance are recommended). The SA0 and SA1 pins correspond to different voltages and numbers. Set an PMBus address by using the formula below. The converter supports dynamic address detection.

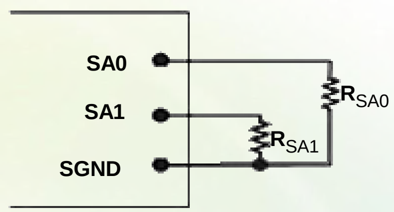


Table 2 Address configuration

R_{SA0}/R_{SA1} [kΩ]	SA0/SA1 [V]	SA0 /SA1
0 - 15	0 - 0.165	0
22	0.198 - 0.242	1
30	0.270 - 0.330	2
51	0.459 - 0.561	3
80.6	0.725 - 0.887	4
113	1.017 - 1.243	5
150	1.350 - 1.650	6
> 220 (including left open)	1.980 - 2.500	7

The PMBus address is determined by the following formula:

PMBusAddress=12 x SA1No. + SA0No.

Theoretically, this formula can generate a maximum of 64 PMBus address, but address 0 and address 12 are prohibited.
For details, refer to PMBus Revision 1.0.

PMBus Commands

The products are PMBus compliant. The following table lists the implemented PMBus commands. For more detailed information see PMBus Power System Management Protocol Specification; Part I – General Requirements, Transport and Electrical Interface and PMBus Power System Management Protocol; Part II – Command Language.

Table 3 Common commands

Designation	Cmd	Impl
Control Commands		
OPERATION	01h	Yes
CLEAR_FAULTS	03h	Yes
STORE_DEFAULT_ALL	11h	Yes
RESTORE_DEFAULT_ALL	12h	Yes
Output Commands		
VOUT_MODE	20h	Yes
VOUT_COMMAND	21h	Yes
VOUT_TRIM	22h	Yes
FREQUENCY_SWITCH	33h	Yes
Fault Alarm Commands		
VOUT_OV_WARN_LIMIT	42h	Yes
VOUT_UV_WARN_LIMIT	43h	Yes
IOUT_OC_WARN_LIMIT	4Ah	Yes
OT_WARN_LIMIT	51h	Yes
VIN_OV_WARN_LIMIT	57h	Yes
VIN_UV_WARN_LIMIT	58h	Yes
Time Sequence Setting Commands		
TON_DELAY	60h	Yes
TON_RISE	61h	Yes
Status Commands		
STATUS_BYTE	78h	Yes
STATUS_WORD	79h	Yes
STATUS_VOUT	7Ah	Yes
STATUS_IOUT	7Bh	Yes
STATUS_INPUT	7Ch	Yes
STATUS_TEMPERATURE	7Dh	Yes
STATUS_CML	7Eh	Yes

Designation	Cmd	Impl
Monitoring Commands		
READ_VIN	88h	Yes
READ_VOUT	8Bh	Yes
READ_IOUT	8Ch	Yes
READ_TEMPERATURE_1	8Dh	Yes
READ_TEMPERATURE_2	8Eh	Yes
READ_TEMPERATURE_3	8Fh	Yes
READ_DUTY_CYCLE	94h	Yes
READ_FREQUENCY	95h	Yes
READ_POUT	96h	Yes
Identification Commands		
PMBus_REVISION	98h	Yes
MFR_ID	99h	Yes
MFR_MODEL	9Ah	Yes
MFR_REVISION	9Bh	Yes
MFR_LOCATION	9Ch	Yes
MFR_DATE	9Dh	Yes
Customized Commands		
MFR_SOFT_VERSION	F3h	Yes
PMBus_CMD_MFR_ISHARE_ENABLE	F8h	Yes
PMBus_CMD_MFR_BARCODE_FIRSTHALF	FAh	Yes
PMBus_CMD_MFR_BARCODE_SECONDHALF	FBh	Yes

NOTE

1. Cmd is short for Command.
2. Impl is short for Implemented.

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Qualification Testing

Parameter	Units	Condition
High Accelerated Life Test (HALT)	4	Lowest operating temperature: -60°C (-76°F); highest operating temperature: 110°C (230°F); vibration limit: 40 G
Proof Of Screen (POS)	4	80 temperature cycles; 50% vibration limit stress: 20 G
High Accelerated Stress Audit (HASA)	8	4 temperature cycles; 50% vibration limit stress: 20 G
Thermal Shock	32	500 temperature cycles between -40°C (-40°F) and +125°C (+257°F) with the temperature change rate of 20°C (68°F) per minute Lasting for 30 minutes both at -40°C (-40°F) and +125°C (+257°F)
Temperature Humidity Bias	16	85°C (185°F); 85% RH; 1000 operating hours under lowest load power
High Temperature Operation Life (HTOL)	16	Rated input voltage; 55°C (131°F); 1000 operating hours under 50% - 80% load power

Thermal Consideration

Thermal Test Point

Sufficient airflow should be provided to ensure reliable operating of the converter. Therefore, thermal components are mounted on the top surface of the converter to dissipate heat to the surrounding environment by conduction, convection and radiation. Proper airflow can be verified by measuring the temperature at the thermal test point.

Figure 20: Thermal test point

NOTE

The temperature at the thermal test point on the converter can not exceed 105°C (221°F). Otherwise, the converter will be protected against overtemperature and will not operate properly.

Power Dissipation

The converter power dissipation is calculated based on efficiency. The following formula reflects the relationship between the consumed power (P_d), efficiency (η), and output power (P_o): Pd=Po(1-η)/η

Thermal Testing Setup

Test board: D x W=254mm x 254mm, 2oz, 4 layers, cross section of the wind tunnel: 800mm x 45mm.

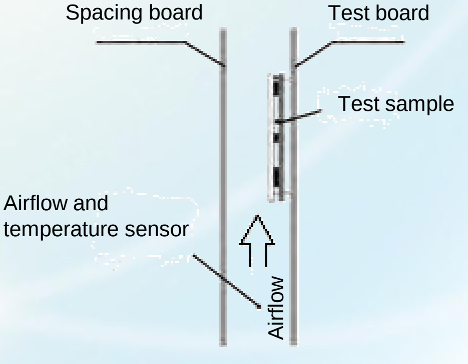

Figure 21: Wind tunnel test setup

Mechanical Consideration

Installation

Although the converter can be mounted in any direction, free airflow must be taken.

Soldering

The converter is compatible with standard wave soldering techniques. When wave soldering, the converter pins should be preheated for 20 - 30 seconds at 110°C (230°F) , and wave soldered at 260°C (500°F) for less than 10 seconds.
When hand soldering, the iron temperature should be maintained at 425°C (797°F) and applied to the converter pins for less than 5 seconds.
The converter can be rinsed using the isopropyl alcohol (IPA) solvent or other proper solvents.

HUAWEI TECHNOLOGIES CO., LTD.
Huawei Industrial Base Bantian Longgang
Shenzhen 518129
People's Republic of China
www.huawei.com