GDQ54S12B-4PD DC-DC Converter

Technical Manual

Issue 1.0

Date 2020-12-25

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About This Document

Purpose

This document describes the GDQ54S12B-4PD DC-DC Converter, including its electrical specifications, features, applications and communication.

The figures provided in this document are for reference only.

Intended Audience

This document is intended for:

- Sales personnel
- Technical support engineers
- System engineers
- Software engineers
- Hardware engineers

Symbol Conventions

The symbols that may be found in this document are defined as follows.

Symbol	Description
DANGER	Indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation which, if not avoided, could result in equipment damage, data loss, performance deterioration, or unanticipated results. NOTICE is used to address practices not related to personal injury.
NOTE	Supplements the important information in the main text. NOTE is used to address information not related to personal injury, equipment damage, and environment deterioration.

Change History

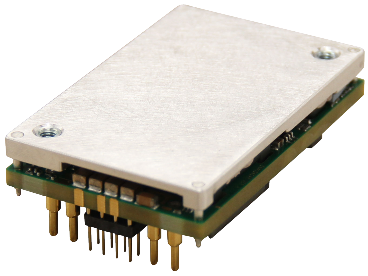
Changes between document issues are cumulative. The latest document issue contains all the changes made in earlier issues.

Issue 1.0 (2020-12-25)

This issue is the first release.

Contents

1 Product Overview



Product Description

The GDQ54S12B-4PD is a new generation isolated DC-DC converter that uses an industry standard quarter-brick structure, featuring high efficiency and power density with low output ripple and noise. It operates from an input voltage range of 36 V to 75 V, and provides the rated output voltage of 12 V as well as the maximum output current of 54 A.

Features

- Efficiency: 95% (T_A = 25°C, V_{in} = 36 V, V_{out} = 12 V, 50% load; T_A = 25°C; V_{in} = 48 V, V_{out} = 12 V, 50% load)
- Length x Width x Height: 57.9 mm x 36.8 mm x 13.4 mm (2.28 in. x 1.45 in. x 0.53 in.)
- Weight: 85 g
- Input undervoltage protection, auxilary undervoltage protection, output overcurrent protection (hiccup mode), output short circuit protection (hiccup mode), output overvoltage protection (hiccup mode) and overtemperature protection (self-recovery)
- Remote on/off
- UL certification
- UL 62368-1, C22.2 No. UL 60950-1, and UL 60950-1 compliant
- RoHS6 compliant

Model Naming Convention

GDQ	54	S	12	B	-	4	P	D
1	2	3	4	5		6	7	8

1 — 48 V input, high performance, digital control, standard quarter-brick

2 — Output current: 54 A

3 — Single output

4 — Output voltage: 12 V

5 — With a baseplate

6 — Pin length: 4.8 mm

7 — PMBus

8 — Version

Applications

- Server
- ATN

2 Electrical Specifications

2.1 Absolute maximum ratings

Table 2-1 Absolute maximum ratings

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input voltage					
• Continuous	-	-	80	V	-
• Transient (100 ms)	-	-	100	V	-
Operating ambient temperature (T_A)	–40	-	85	°C	-
Storage temperature	–55	-	125	°C	-
Operating humidity	10	-	95	% RH	Non-condensing
External voltage applied to ON/OFF	-	-	12	V	-
External voltage applied to PMBus	-	-	3.6	V	-
Altitude	-	-	3000	m	Basic insulation
	-	-	5000	m	Functional insulation

NOTE

When the input voltage is 75–80 V, the converter must not be damaged. Not all the characteristic parameters should be conform to the specification.

2.2 Input

Table 2-2 Input specification

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Operating input voltage	36	48	75	V	-
Maximum input current	-	-	35	A	V_{in} = 32–75 V; I_{out} = I_{onom}
No-load loss	-	-	11	W	V_{in} = 48 V, V_{out} = 12 V, T_A = 25°C
	-	-	9.5	W	V_{in} = 48 V, V_{out} = 7.9 V, T_A = 25°C
Standby loss	-	-	2	W	V_{in} = 48 V, V_{out} = 12 V, T_A = 25°C (CNT OFF)
Input capacitance	390	860	-	µF	T_A = –5°C to +65°C; aluminum electrolytic capacitor
	440 (See NOTE)	860	-	µF	T_A = –40°C to +85°C; aluminum electrolytic capacitor
Response to Input Transient	-	-	650	mV	Input voltage DIP test (37–72 V). Output voltage range: 11.75 V ≤ V_{out} ≤ 12.95 V. The time when the overshoot voltage recovers to 12.6 V is less than 400 µs (set voltage: 12.3 V). Output capacitor: 1500 µF and 10 x 10 µF MLCC

NOTE

- If T_A < –5°C, the ESR of the input of an additional electrolytic capacitor should be less than 10 Ω.

2.3 Output

Table 2-3 Output specification

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Output voltage setpoint	11.88	12	12.12	V	V_{in} = 48 V, V_{out} = 12 V, I_o = 27 A, T_A = 25°C
	12.2	12.3	12.4	V	V_{in} = 48 V, V_{out} = 12.3 V (adjusted by PMBus), I_o = 27 A, T_A = 25°C
	7.8	7.9	8.0	V	V_{in} = 48 V, V_{out} = 7.9 V (adjusted by PMBus), I_o = 5 A, T_A = 25°C
Output voltage	11.64	12	12.36	V	V_{out} = 12 V, T_A = –40°C to +85°C
	12	12.3	12.6	V	T_A = –5°C to +65°C, V_{out} = 12.3 V (adjustable by PMBus), P_{out} = 0–650 W
	7.6	7.9	8.2	V	T_A = –5°C to +65°C, V_{out} = 7.9 V (adjustable by PMBus), P_{out} = 0–75 W
Output current	0	-	54	A	P_{out} ≤ 650 W
Output power	0	-	650	W	V_{out} = 12 V/12.3 V
	0	-	75	W	V_{out} = 7.9 V
Line regulation	–0.5	-	0.5	%	-
Load regulation	–1.5	-	1.5	%	V_{in} = 48 V; T_A = –5°C to +65°C (IT customization)
	–3	-	3	%	V_{in} = 48 V; T_A = –40°C to +85°C
Regulated voltage precision	–2.5	-	2.5	%	T_A = –5°C to +65°C
	–3	-	3	%	T_A = –40°C to +85°C
Temperature coefficient	–0.02	-	0.02	%/°C	T_A = –40°C to +85°C

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
External capacitance	660 (See NOTE)	-	13000	µF	V_{out} = 12 V; SMD aluminum solid capacitor or chip aluminum capacitor, the ESR should be less than 30 mohm.
Ripple and noise (peak to peak)	-	-	500	mV	Oscilloscope bandwidth: 20 MHz
Output voltage adjustment	6	-	12.5	V	Adjust the voltage by the PMBus
Output voltage adjustment rate	27	32	40	V/S	Adjust the voltage by the PMBus
Output voltage overshoot	-	-	5	%	-
Output voltage delay time	-	-	100	ms	-
CNT startup/shut dowm delay time	-	-	40	ms	-
Output voltage adjustment delay time	-	-	10	ms	From receive command to output voltage change
Output voltage rise time	6	-	12	ms	V_{out} = 7.9 V
	12	-	24	ms	V_{out} = 12 V
Switching frequency	-	180	-	kHz	-

NOTE

- If T_A < –5℃, the type of the output of the external capacitance should be SMD solid aluminum capacitor, and the value at least 2 x 660 µF. During the equipment test, the layout distance of minimum capacitor must be extended to less than 5 cm.
- The load of the module is recommended to be at least 4 mA to avoid a probable floating output voltage.

2.4 Efficiency

Table 2-4 Efficiency specification

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
100% load	92.5	93.5	-	%	T_A = 25°C, V_{in} = 48 V, V_{out} = 12 V
50% load	94	95	-	%	

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
20% load	92	93	-	%	
100% load	92.5	93.5	-	%	T_A = 25°C, V_{in} = 36 V, V_{out} = 12 V
50% load	94	95	-	%	
100% load	92	93	-	%	T_A = 25°C, V_{in} = 75 V, V_{out} = 12 V
50% load	92.5	93.5	-	%	
3A load	75	-	-	%	T_A = 25°C, V_{in} = 48 V, V_{out} = 7.9 V
7A load	84	-	-	%	

2.5 Protection

Table 2-5 Input protection

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input undervoltage protection startup threshold	32	34	36	V	-
Input undervoltage protection shutdown threshold	30	32	34	V	
Input undervoltage protection hysteresis	1	2	3	V	
Auxilary undervoltage protection startup threshold	23.5	26.9	30	V	-
Auxilary undervoltage protection shutdown threshold	22	25.4	29	V	-
Auxilary undervoltage protection hysteresis	0.8	1.6	2.3	V	-
Input overvoltage warning alarm threshold	80	85	-	V	Input overvoltage greater than 5 ms need to be reported.
Input overvoltage warning alarm clearance threshold	75	80	-	V	
Input overvoltage warning hysteresis	1	5	-	V	

Table 2-6 Output protection

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Output overcurrent protection	110	-	140	% I_{omax}	Hiccup mode
	105	-	-	% I_{omax}	Hiccup mode; hiccup period is more than 2s (typical value is 2.5s); protection delay time is more than 100 ms (typical value is 150 ms), during the delay time, output voltage is 11.6 V to 12.6 V (type value is 12.3 V, adjustable by PMBus).
	130	-	-	% I_{omax}	Hiccup mode; hiccup period is more than 2s (typical value is 2.5s); protection delay time is more than 4 ms (typical value is 8 ms), during protection delay time, output voltage is not requested (typical value is 12.3 V, adjustable by PMBus).
Output short circuit protection	150	-	-	% I_{omax}	Hiccup mode, hiccup period is more than 2s (typical value is 2.5s); response time of output short circuit protection is no more than 0.5 ms. Short circuit impedance is not less than 120 milliohms.
Output overvoltage protection	13.2	-	16	V	Hiccup mode, 15 V < V_{out} < 16 V, over 100 ms, need protect.
Overtemperature protection threshold	105	120	130	°C	Self-recovery; the values are obtained by measuring the temperature of the PCB near the temperature sensor.
Overtemperature protection hysteresis	5	-	-	°C	

2.6 Dynamic Characteristics

Table 2-7 Dynamic characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Overshoot amplitude	-	-	450	mV	T_A = –5°C to +65°C, V_{out} = 12.3 V (adjustable by PMbus); current change rate: 0.5 A/µs, T = 10 ms; output parallel capacitance is 1500 µF and 10 x 10 µF MLCC; Load: 25%–50%–25%; 50%–75%–50%; 75%–100%–75%
Overshoot recovery time (customized)	-	-	300	µs	
Overshoot amplitude	–1500	-	300	mV	T_A = –5°C to +65°C, V_{out} = 7.9 V (adjustable by PMbus); current change rate: 0.5 A/µs, T = 10 ms; output parallel capacitance is 1500 µF and 10 x 10 µF MLCC; Load: 1 A–10 A–1 A
Overshoot recovery time (customized)	-	-	300	µs	
Overshoot amplitude	-	-	600	mV	Current change rate: 0.1 A/µs, T = 10 ms, V_{out} = 12 V; Load: 25%–50%–25%; 50%–75%–50%; 75%–100%–75%
Overshoot recovery time	-	-	400	µs	

2.7 Parallel characteristics

Table 2-8 Parallel characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Maximum parallel output power (See **NOTE**)	-	-	300 x n	W	Number of parallel modules ≥ 2; with back-up
	-	-	600 x n	W	Number of parallel modules ≥ 2; without back-up
Unbalance of current equalization	–5	-	5	%	V_{out} = 12 V, I_{out} > 30 A (single module)
	–10	-	10	%	V_{out} = 12 V, 15 A ≤ I_{out} ≤ 30 A (single module)
Maximum parallel start load	-	-	650	W	CC mode, number of parallel modules ≥ 2 pcs

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
	-	-	1300	W	CR mode, number of parallel modules ≥ 2 pcs
Maximum output voltage delay time	-	-	8	s	-
Current equalization adjustment	-	-	0.24	V	Current equalization adjustment refers to the adjustment of the difference between the output voltages of modules with 48 V input and half-load output.
Minimum Rds (on) of Oring mosfet	0.3	-	-	mΩ	T_A = 25°C; 3 PCS mosfet are connected in parallel.

NOTE

- All of the SYNC pins should connect to each other together, but when some module is disabled, its SYNC should be isolated.
- All of the ISHARE pins should connect to each other together.
- Max parallel number is 12, when parallel number n ≥ 2, maximum parallel start load is 650 W.
- Proportional current sharing is supported.
- The switching frequency adjustment function is supported, the adjustable nodes are 175 kHz, 180 kHz, 185 kHz. This function is only applicable to the 2 module parallel scenario.
- The gain adjustment function of the current sharing bus is supported, and the gain adjustment gear is 1, 1.05, 1.1, 1.15, 1.2. This function is only applicable to the 2 module parallel scenario.
- For the application scenario of 4 PCS parallel power module with CR full load startup, the independent power supply mode needs to be set by the PMBus, and the SYNC pins are connected in pairs.

2.8 Insulation Characteristics

Table 2-9 Insulation characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input to output insulation voltage	-	-	1500	V	Basic insulation (1-minute test); altitude = 3000 m Substrate and heatsink require floating and must not be connected to chassis or ground.
Input to baseplate insulation voltage	-	-	750	V	
Output to baseplate insulation voltage	-	-	750	V	
Input to output insulation voltage	-	-	1500	V	Functional insulation (1-minute test); altitude = 5000 m

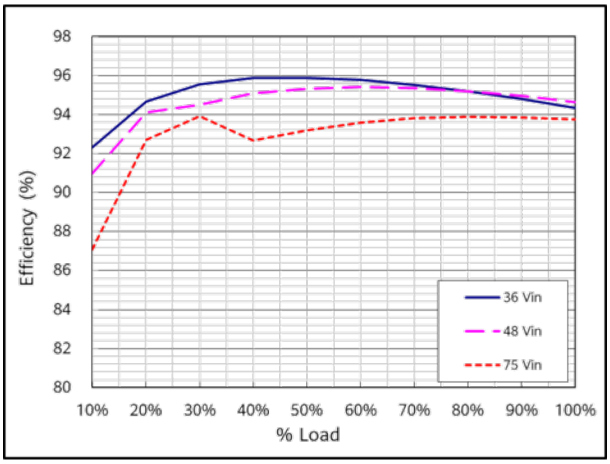
Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input to baseplate insulation voltage	-	-	750	V	
Output to baseplate insulation voltage	-	-	750	V	

2.9 Other Characteristics

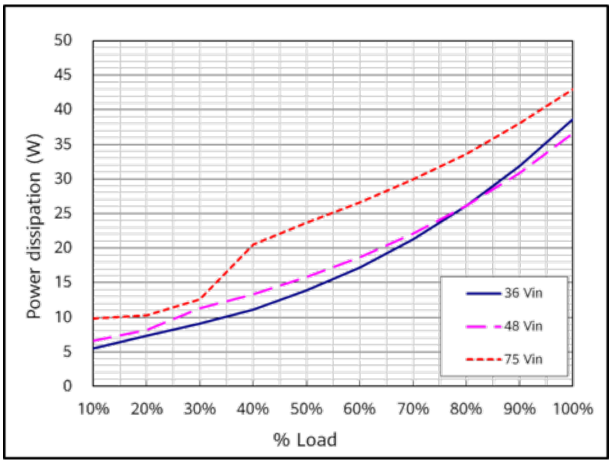
Table 2-10 Other characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Remote On/Off voltage low level	–0.7	-	1.2	V	Negative logic
Remote On/Off voltage high level	3.5	-	12	V	
On/Off current low level	-	-	1.0	mA	-
On/Off current high level	-	-	-	μA	
PMBus_CTL voltage low level	0	-	0.8	V	High level effective
PMBus_CTL voltage high level	2.1	-	3.3	V	
PMBus_CTL current low level	-	-	1	mA	-
Mean time between failures (MTBF)	-	2.5	-	Million hours	Telcordia, SR332 Method 1 Case 3; 80% load, normal input/rated output; 300 LFM; T_A = 40°C

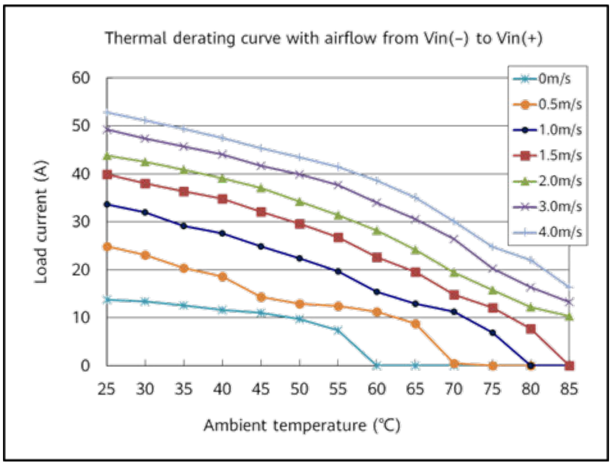
3 Characteristic Curves



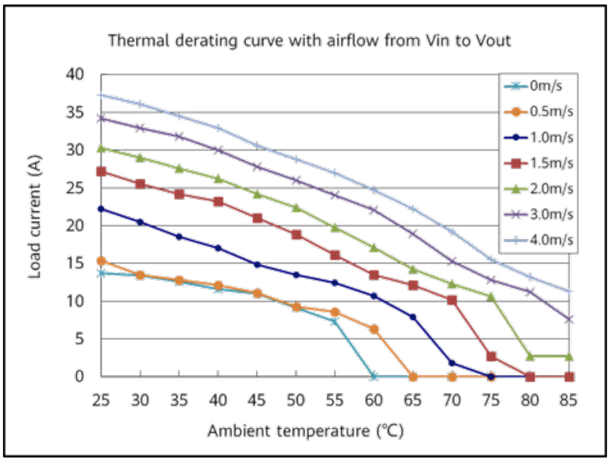
Efficiency curve (T_A = 25°C; V_{out} = 12 V)



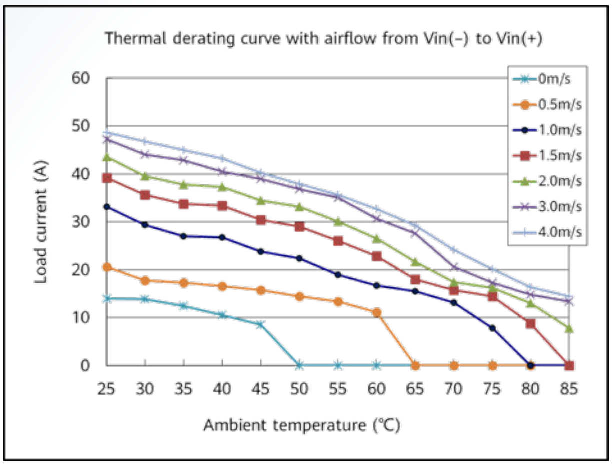
Power dissipation curve (T_A = 25°C; V_{out} = 12 V)



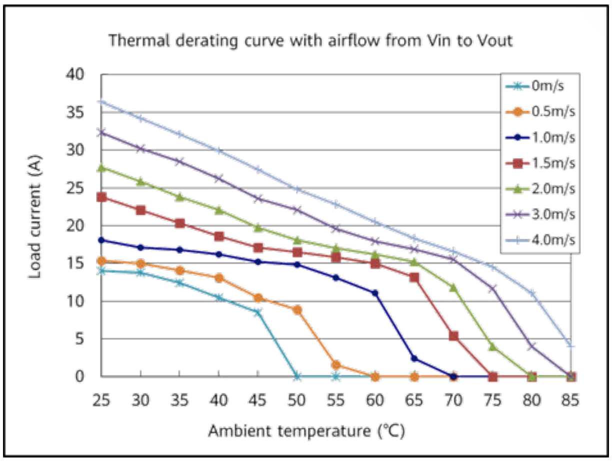
Thermal derating with airflow from V_{in}(–) to V_{in}(+) (V_{in} = 48 V; V_{out} = 12 V)



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



Thermal derating with airflow from V_{in}(–) to V_{in}(+) (V_{in} = 60 V; V_{out} = 12 V)



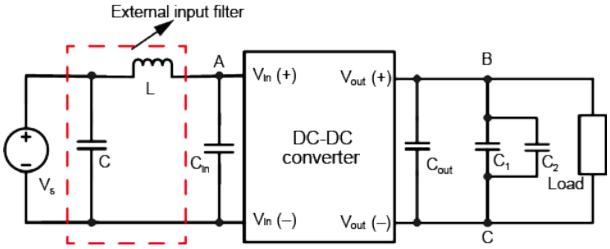
Thermal derating with airflow from V_{in} to V_{out} (V_{in} = 60 V; V_{out} = 12 V)

4 Typical Waveforms

NOTE

1. During the test of input reflected ripple current, the input must be connected to an external input filter (including a 12 µH inductor and a 220 µF electrolytic capacitor), which is not required in other tests.
2. Points B and C are for testing the output voltage ripple.

Figure 4-1 Test set-up diagram



C_{in}:

- The 440 µF aluminum electrolytic capacitor is recommended (T_A = –40°C to +85°C).
- The 390 µF aluminum electrolytic capacitor is recommended (T_A = –5°C to +65°C).

C_{out}: The 660 µF SMD aluminum solid capacitor or chip aluminum capacitor is recommended (ESR < 30 mΩ). (See **Note**)

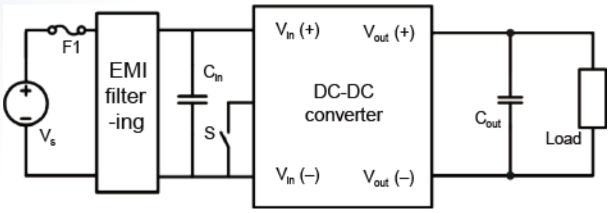
C_1: The 0.1 µF ceramic capacitor is recommended.

C_2: The 10 µF aluminum electrolytic capacitor is recommended.

NOTE

- If T_A < –5°C, the type of the output of the external capacitance should be SMD aluminum solid capacitor, and the value at least 2 x 660 µF.

Figure 4-2 Typical circuit applications



F_1: The 35 A fuse (fast-blow)

C_{in}:

- The 440 μF aluminum electrolytic capacitor is recommended (T_A = –40°C to +85°C).
- The 390 μF aluminum electrolytic capacitor is recommended (T_A = –5°C to +65°C).

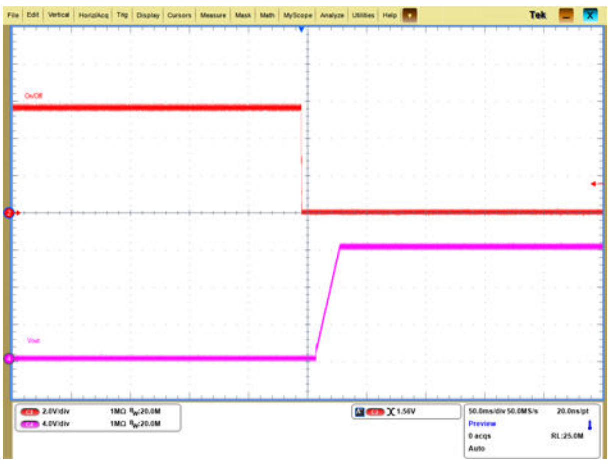
C_{out}: The 660 μF SMD aluminum solid capacitor or chip aluminum capacitor is recommended (ESR < 30 mΩ). (See **Note**)

NOTE

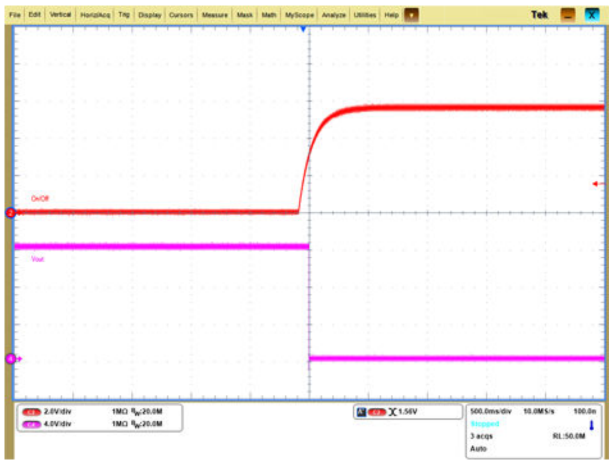
- If T_A < –5°C, the type of the output of the external capacitance should be SMD aluminum solid capacitor, and the value at least 2 x 660 μF.

4.1 Turn-on/Turn-off

Conditions: T_A = 25°C unless otherwise specified

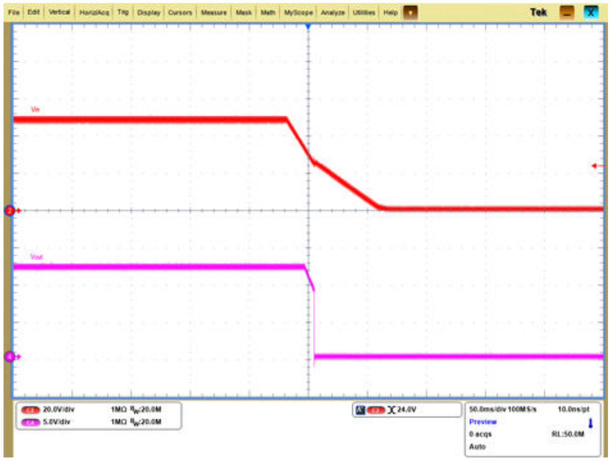


Startup from On/Off



Shutdown from On/Off

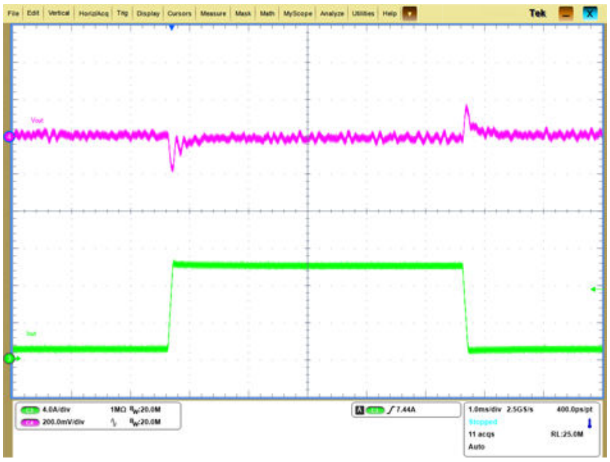
Startup by power-on



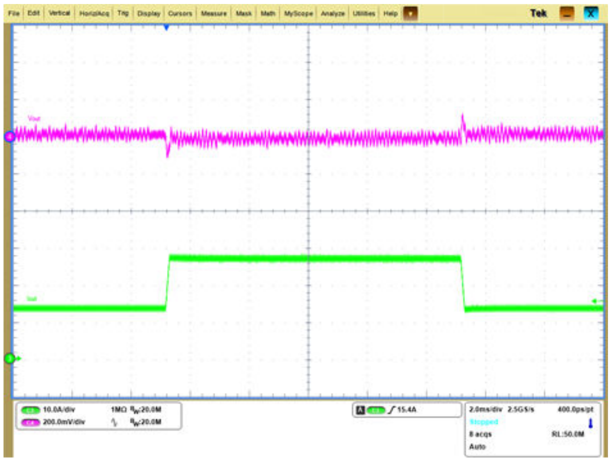
Shutdown by power-off

4.2 Output Voltage Dynamic Response

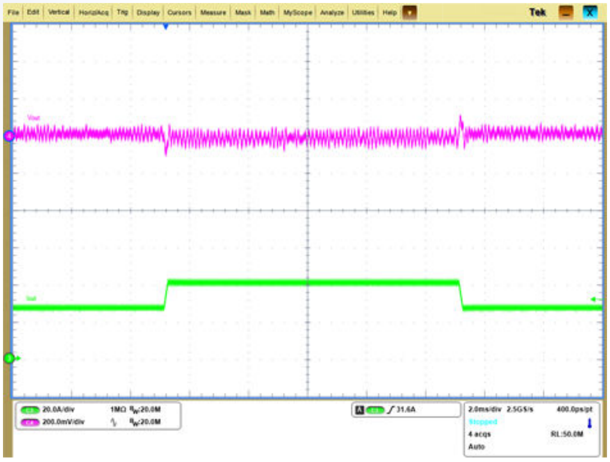
Conditions: T_A = 25°C unless otherwise specified



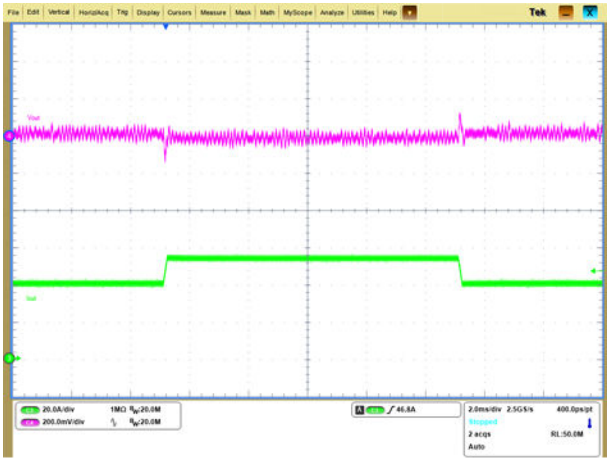
Load: 1A–10 A–1 A, T = 10 ms, di/dt = 0.5 A/µs, V_{out} = 7.9 V



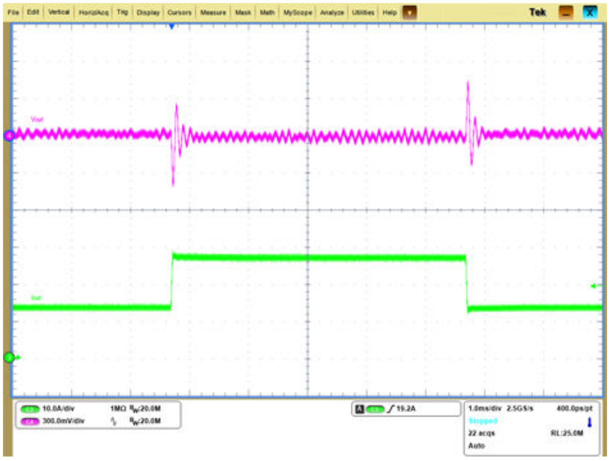
Load: 25%–50%–25%, di/dt = 0.1 A/µs, V_{out} = 12 V



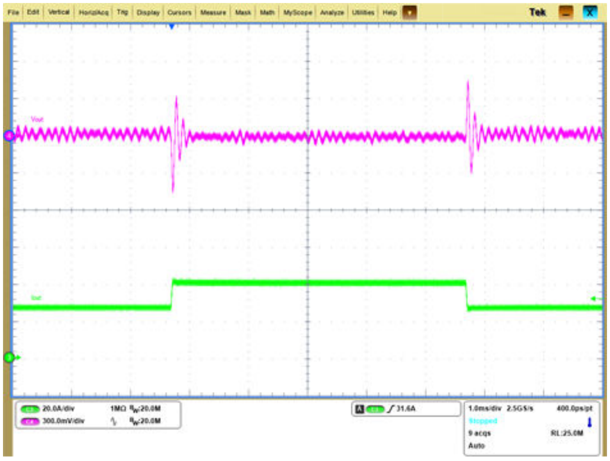
Load: 50%–75%–50%, di/dt = 0.1 A/μs, V_{out} = 12 V



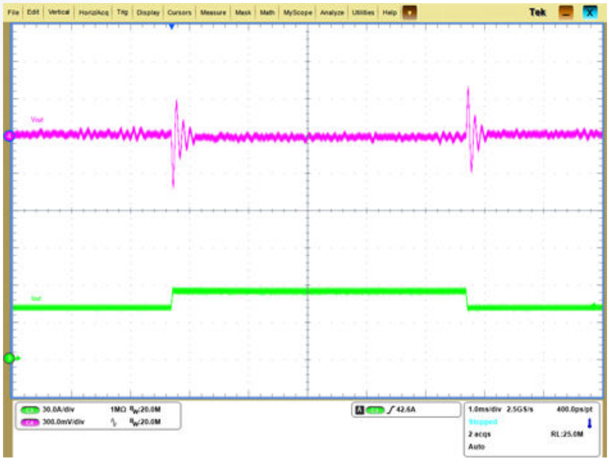
Load: 75%–100%–75%, di/dt = 0.1 A/μs, V_{out} = 12 V



Load: 25%–50%–25%, T = 10 ms, di/dt = 0.5 A/μs, V_{out} = 12.3 V



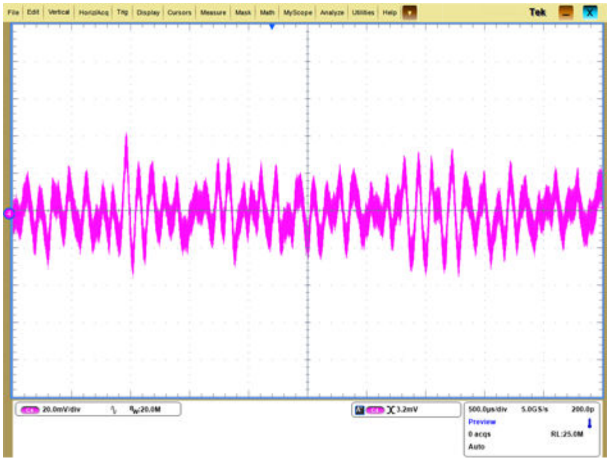
Load: 50%–75%–50%, T = 10 ms, di/dt = 0.5 A/μs, V_{out} = 12.3 V



Load: 75%–100%–75%, T = 10 ms,
di/dt = 0.5 A/μs, V_{out} = 12.3 V

4.3 Output Voltage Ripple

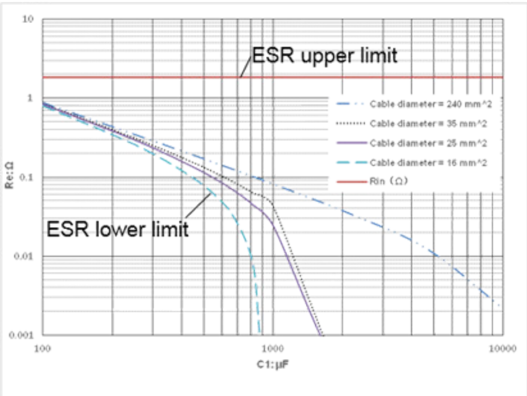
Conditions: T_A = 25°C unless otherwise specified



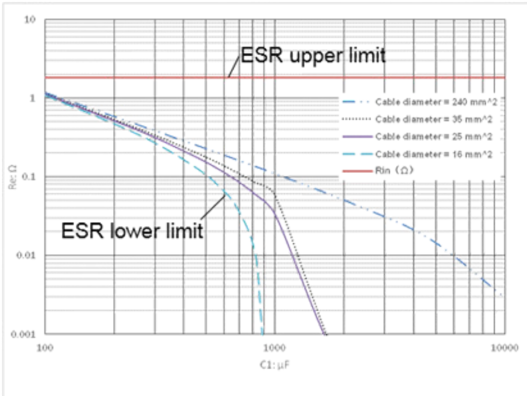
V_{in} = 48 V, V_{out} = 12 V, I_{out} = 54 A

5 Input Anti-resonance Application Guide

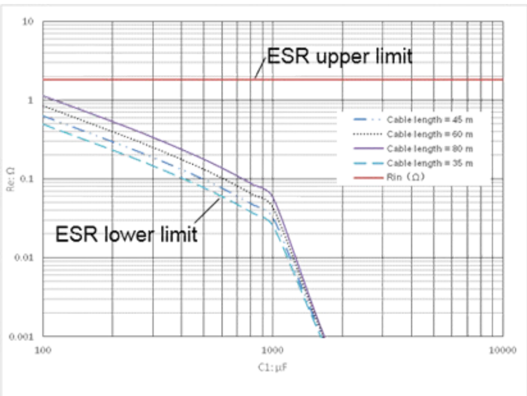
In the input remote power supply application, the parasitic inductor of the remote power supply cable and the input capacitor as well as the power brick may resonate, causing the power input voltage to be unstable. As a result, the PSU may experience a power outage due to undervoltage. Therefore, it is recommended that input capacitors be selected according to the input capacitor ESR conditions. Select the appropriate curve based on the application scenario, and ensure that the input capacitor ESR is within the upper and lower limits in the curve. Then there will be no input resonance.



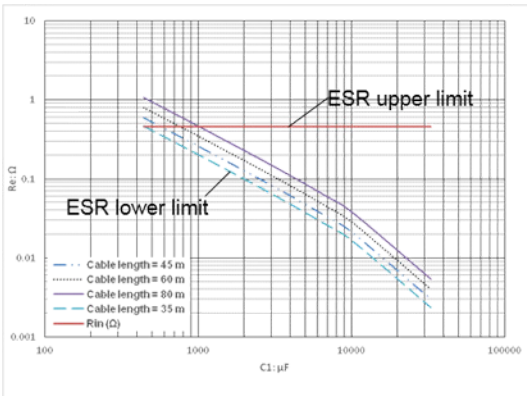
Cable length = 60 m, V_{in} = 36 V, I_{out} = 54 A, T_A = –40°C



Cable length = 80 m, V_{in} = 36 V, I_{out} = 54 A, T_A = –40°C



Cable diameter = 35 mm^2, V_{in} = 36 V, I_{out} = 54 A, T_A = –40°C



Cable diameter = 240 mm^2, V_{in} = 36 V, I_{out} = 216 A, T_A = –40°C

6 Remote On/Off

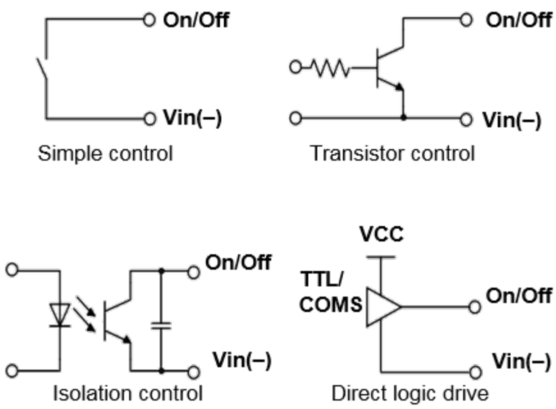
The main output of module can be turned on or turned off by On/Off signal.

On/Off Pin Level	Status
Low level [–0.7 V, 1.2 V]	On
High level [3.5 V, 12.0 V]	Off

NOTE

The output is of an uncertain state when CNT level is 1.2–3.5 V.

Figure 6-1 Various circuits for driving the On/Off pin



7 Protection Characteristics

- **Input Undervoltage Protection**

  The converter will shut down after the input voltage drops below the undervoltage protection threshold. The converter will start to work again after the input voltage reaches the input undervoltage recovery threshold. For the hysteresis, see **Input protection**.

- **Output Overvoltage Protection**

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

- **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 setpoint, the converter enters 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 converter. 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 the overtemperature protection hysteresis.

8 Communication

8.1 Signal Specification

Table 8-1 PMBus signal interface characteristics

Parameter	Min.	Max.	Unit	Notes & Conditions
Logic Input Low (V_{IL})	-	0.8	V	-
Logic Input High (V_{IH})	2.1	3.6	V	-
Logic output Low (V_{OL})	-	0.4	V	I_{oL} = –6 mA
Logic output High (V_{OH})	2.4	3.6	V	I_{oH} = 6 mA
PMBus setting-up time	250	-	nS	See **Figure 8-2**
PMBus holding time	300	-	nS	

Table 8-2 PMBus detection precision

Parameter	Min.	Max.	Unit	Notes & Conditions
Input voltage detection precision	–2	2	V	-
Output voltage detection precision	–0.2	0.2	V	
Output current detection precision	–2	2	A	25°C ≤ T_A ≤ 85°C, when the module is turned on, the minimum value of the reported current is 0.25 A.
	–5	5	A	–40°C ≤ T_A < +25°C, when the module is turned on, the minimum value of the reported current is 0.25 A.

Parameter	Min.	Max.	Unit	Notes & Conditions
Temperature detection precision	–5	5	°C	T_A = –40°C to +125°C

8.2 Data Link Layer Protocol

The link layer uses the PMBus V1.2 protocol and complies with *PMBus_Specification_Part_I_Rev_1-2_20100906* and *PMBus_Specification_Part_II_Rev_1-2_20100906*.

8.2.1 PMBus Address

The following table describes the mapping between the SA0, SA1 and PMBus address. When the SA0 and SA1 left open, PMBus address is 0X5B. When the SA0 and SA1 connect to GND, PMbus address is 0, which is prohibition of use. The PMBus address can be calculated as D:

D = 12 x SA1 + SA0

D is the corresponding decimal number of PMBus address data.

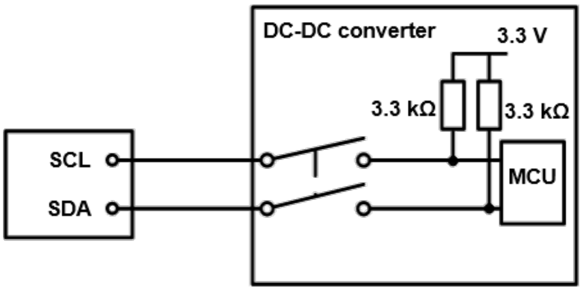
R_{SA1} (kΩ)	SA1 (V)	SA1 Address (DEC)
0–0.33	0–0.6	0
Left open	2.2–3.3	7

R_{SA0} (kΩ)	SA0 (V)	SA0 Address (DEC)
1–15	0–0.165	0
22	0.198–0.242	1
30	0.270–0.330	2
51	0.459–0.561	3
80.6	0.725–0.886	4
113	1.017–1.243	5
150	1.350–1.650	6
> 220 (Left open)	1.980–2.500	7

8.2.2 SCL and SDA

The SCL and SDA are each connected to a pull-up resistor and connected to the communication bus through the fault isolation circuit.

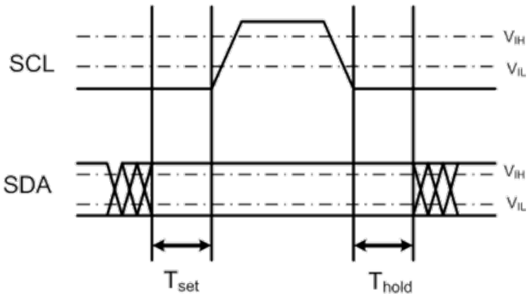
Figure 8-1 Interconnect diagram of SCL and SDA



SCL, SDA Signal	Min.	Typ.	Max.
Low level	-	-	0.8 V
High level	2.1 V	-	3.6 V

The converter supports the 100 kHz (default) and 400 kHz clock rate. 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. Communication will fail if the time is not consistent with the specifications.

Figure 8-2 PMBus setup time and hold-up time



8.3 Network Layer Protocol

8.3.1 Slave Addressing Method

The converter serves as the slave device, and the converter address is identified by the hardware and assigned in static mode. The master device accesses slave devices independently based on the slave device addresses determined by the hardware.

8.3.2 Checksum

To ensure data integrity and accuracy during communication, the converter uses the 8-bit CRC checksum mechanism.

The last byte sent for each communication is the CRC checksum for the communication data. For example, the last byte of the data returned by the converter is the checksum.

The CRC checksum is generated using the multinomial: CRC8.

8.3.3 Data Transmission

The converter complies with standard PMBus communication data formats. The data in each PMBus communication data format carries the CRC checksum.

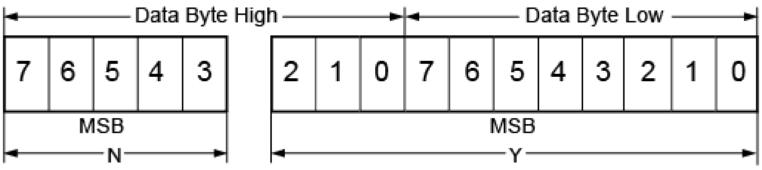
8.4 Application Layer Protocol

8.4.1 Data Format

Linear 11 Data Format

The linear data format is a two-byte value with a 11-bit binary signed mantissa (two's complement) and a 5-bit binary signed exponent (two's complement), as shown in the following figure.

Figure 8-3 Linear 11 data format



The relationship between N, Y, and actual value X is given by the following equation:

$$X = Y \times 2^{N}$$

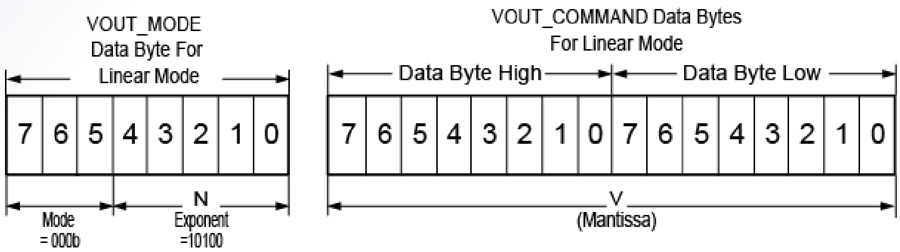
Where:

- Y is the 11-bit, binary signed mantissa (two's complement).
- N is the 5-bit, binary signed exponent (two's complement).

Linear 16 Data Format

The linear data format consists of two parts, with a 16-bit binary unsigned mantissa and a 5-bit binary signed exponent (two's complement), as shown in the following figure.

Figure 8-4 Linear 16 data format



The output voltage is calculated as follows:

$$Voltage = V \times 2^N$$

Where:

- Voltage is the output voltage value.
- V is the 16-bit unsigned integer.
- N is the 5-bit signed integer (two's complement). N = –12

8.5 Commands

Hex Code	Command Name	Data Type	Data Format
0x01	OPERATION	Read/Write Byte	-
0x03	CLEAR_FAULTS	Send Byte	-
0x11	STORE_DEFAULT_ALL	Send Byte	-
0x20	VOUT_MODE	Read Byte	-
0x21	VOUT_COMMAND	Read/Write Word	Linear 16 (Q10)
0x40	VOUT_OV_FAULT_LIMIT	Read/Write Word	Linear 16 (Q9)
0x42	VOUT_OV_WARNNING_LIMIT	Read/Write Word	Linear 16 (Q9)
0x46	IOUT_OC_FAULT_LIMIT	Read/Write Word	Linear 11 (Q3)
0x4A	IOUT_OC_WARNNING_LIMIT	Read/Write Word	Linear 11 (Q4)
0x4F	OT_FAULT_LIMIT	Read/Write Word	Linear 11 (Q3)
0x51	OT_WARNNING_LIMIT	Read/Write Word	Linear 11 (Q3)
0x59	VIN_UV_FAULT_LIMIT	Read/Write Word	Linear 11 (Q3)
0x58	VIN_UV_WARNNING_LIMIT	Read/Write Word	Linear 11 (Q3)
0x78	STATUS_BYTE	Read Byte	-

Hex Code	Command Name	Data Type	Data Format
0x79	STATUS_WORD	Read Word	-
0x7A	STATUS_VOUT	Read Byte	-
0x7B	STATUS_IOUT	Read Byte	-
0x7C	STATUS_INPUT	Read Byte	-
0x7D	STATUS_TEMPERATURE	Read Byte	-
0x7E	STATUS_CML	Read Byte	-
0x88	READ_VIN	Read Word	Linear 11 (Q3)
0x8B	READ_VOUT	Read Word	Linear 16 (Q10)
0x8C	READ_IOUT	Read Word	Linear 11 (Q3)
0x8D	READ_TEMPERATURE	Read Word	Linear 11 (Q2)
0x95	READ_FREQUENCY	Read Word	Linear 11 (Q0)
0x96	READ_POUT	Read Word	Linear 11 (Q0)
0x60	TON_DELAY	Read/Write Word	Linear 11 (Q0)
0xF3	SOFT_VERSION	Read Word	-
0xD1	SOFT_VERSION	Read Word	-
0xF6	PCB_VERSION	Read Word	-
0x98	PMBUS_VERSION	Read Byte	-
0x99	MFR_ID	Read Block	ASCII
0x9A	MFR_MODEL	Read Block	ASCII
0x9B	MFR_REVISION	Read Block	ASCII
0x9C	MFR_LOCATION	Read Block	ASCII
0x9D	MFR_DATE	Read Block	ASCII
0xD0	PROTOCOL_TYPE	Read Word	-
0xFA	PMBUS_READ_BARCODE_HEADER	Read/Write Block	-
0xFB	PMBUS_BARCODE	Read/Write Block	-
0xF8	SOFTLOAD_INFO	Read Block	-
0xFC	SOFTLOAD_CTRL	Read/Write Word	Unsigned

Hex Code	Command Name	Data Type	Data Format
0xFD	MFR_DEVICE_ID	Read/Write Block	R: ASCII W: binary
0xFE	SOFTLOAD_CTRL_EX	Write Block	Unsigned
0xEA	WRITE_BBOX_FRAME_ID	Read/Write Word	Unsigned
0xEB	READ_BBOX_FRAME_DATA	Read Block	Unsigned
0xEF	READ_BBOX_FRAME_NUM	Read Word	Unsigned

8.6 Command Descriptions

OPERATION (0x01)

Powers on or off the converter or clears the latch-off state.

Function	Data Byte
Start converter	0x80
Reset converter	0x00

CLEAR_FAULTS (0x03)

Clear error history fault information.

STORE_DEFAULT_ALL (0x11)

Save data after data calibration. If this command is not sent, the data will be lost after a power failure.

VOUT_MODE (0x20)

This command is used to determine the data type and parameters using PMBus command.

VOUT_COMMAND (0x21)

Changes the output voltage of the converter. The default value is 12 V. Voltage adjustment range: 6.0 V to 12.5 V.

STATUS_WORD (0x79)

Bit No.	Command Name
Bit 15	VOUT_FAULT_OR_WARNING
Bit 14	IOUT_POUT_FAULT_OR_WARNING
Bit 13	VIN_OR_IIN_FAULT_OR_WARNING
Bit 12	MFR_SPECIFIC_FAULT_OR_WARNING
Bit 11	POWER_GOOD_NOT
Bit 10	FAN_FAULT (unused)
Bit 9	RESERVED1 (unused)
Bit 8	UNKNOWN_FAULT (unused)
Bit 7	BUSY_STATUS (unused)
Bit 6	OFF_STATUS
Bit 5	VOUT_OV_FAULT
Bit 4	IOUT_OC_FAULT
Bit 3	VIN_UV_FAULT
Bit 2	TEMPERATURE_FAULT_OR_WARNING
Bit 1	CML_FAULT
Bit 0	MORE_FAULT_IN_HIGH

STATUS_VOUT (0x7A)

Bit No.	Command Name
Bit 7	OV_FAULT
Bit 6	OV_WARN
Bit 5	UV_WARN (unused)
Bit 4	UV_FAULT (unused)
Bit 3	VOUT_MAX_WARN (unused)
Bit 2	TON_MAX_FAULT (unused)
Bit 1	TOFF_MAX_WARN (unused)
Bit 0	VOUT Tracking Error (unused)

STATUS_IOUT (0x7B)

Bit No.	Command Name
Bit 7	OC_FAULT
Bit 6	OC_LV_FAULT (unused)
Bit 5	OC_WARN
Bit 4	UC_FAULT (unused)
Bit 3	Current Share Fault (unused)
Bit 2	In Power Limiting Mode (unused)
Bit 1	OP_FAULT (unused)
Bit 0	OP_WARNING (unused)

STATUS_INPUT (0x7C)

Bit No.	Command Name
Bit 7	OV_FAULT (unused)
Bit 6	OV_WARN
Bit 5	UV_WARN
Bit 4	UV_FAULT
Bit 3	Unit Off For Low Input Voltage (unused)
Bit 2	OC_FAULT (unused)
Bit 1	OC_WARN (unused)
Bit 0	OP_WARN (unused)

STATUS_TEMPERATURE (0x7D)

Bit No.	Command Name
Bit 7	OT_FAULT
Bit 6	OT_WARNING
Bit 5	UT_WARNING (unused)
Bit 4	UT_FAULT (unused)

Bit No.	Command Name
Bit 3	Reserved
Bit 2	Reserved
Bit 1	Reserved
Bit 0	Reserved

STATUS_CML (0x7E)

Bit No.	Command Name
Bit 7	INVALID_CMD
Bit 6	INVALID_DATA
Bit 5	PEC_FAILED
Bit 4	MEMORY_FAULT
Bit 3	PROC_FAULT
Bit 2	Reserved
Bit 1	COMM_OTHER_FAULT
Bit 0	OTHER_FAULT

9 Mechanical Overview

Figure 9-1 Mechanical overview

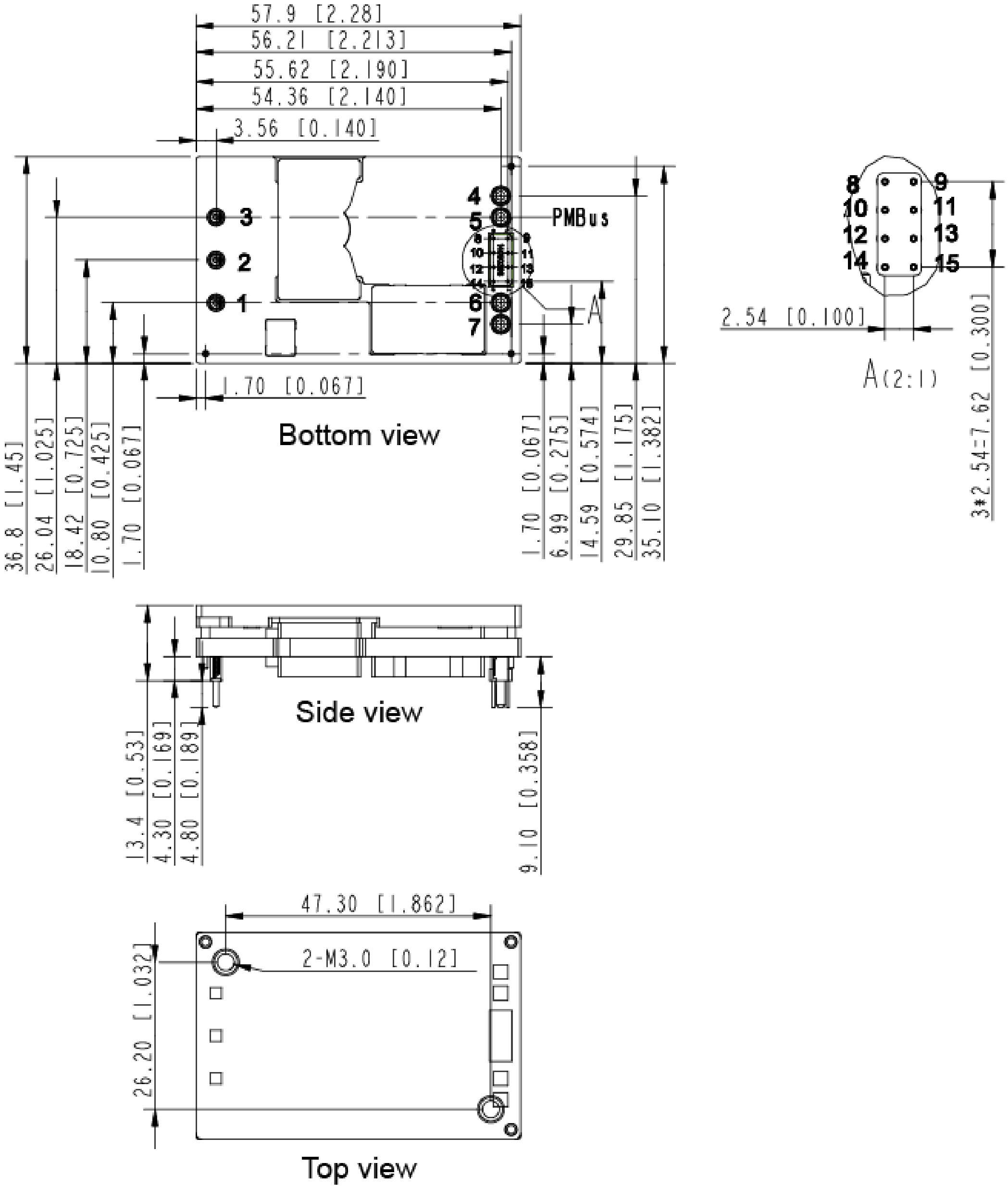


Table 9-1 Pin description

Pin No.	Pin name	Pin No.	Pin name
1	Vin+	9	SA0
2	ON/OFF	10	SYNC
3	Vin–	11	SA1
4	Vout–	12	PMBus_CTL
5	Vout–	13	ISHARE
6	Vout+	14	PMBus_SCL
7	Vout+	15	PMBus_SDA
8	GND	-	-

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. Pins 1–3 are 1.00 ± 0.05 mm [0.040 ± 0.002in.] diameter with 2.00 ± 0.10 mm [0.080 ±0.004 in.] diameter standoff shoulders.

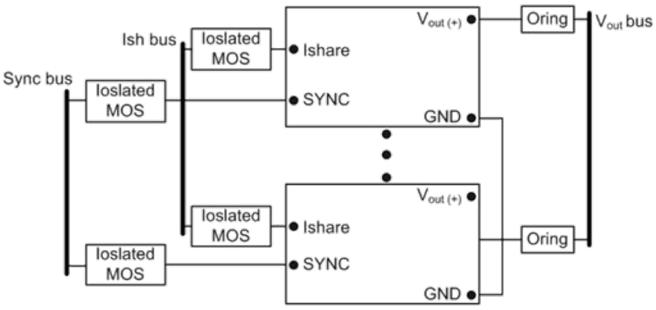
   Pins 4–7 are 1.50 ± 0.05 mm [0.060± 0.002 in.] diameter with 2.50 ± 0.10 mm[0.098 ± 0.004 in.] diameter standoff shoulders.

   Pins 8–15 are 0.50 ± 0.05 mm [0.020 ± 0.002 in.] diameter standoff shoulders.
3. M3 screw used to bolt unit is baseplate to other surfaces (such as heats ink) must not exceed 4.0 mm [0.157 in.] depth blow the surface of baseplate. GB9074.4-88 M3 x 6 cross recessed pan head with spring washer and flat washer combination screw is recommended.
4. Components will vary between models.

10 Parallel Operation

In constant resistance mode (CR mode), the maximum number of parallel modules is 12. In constant current mode (CC mode), the maximum number of parallel modules is 12.

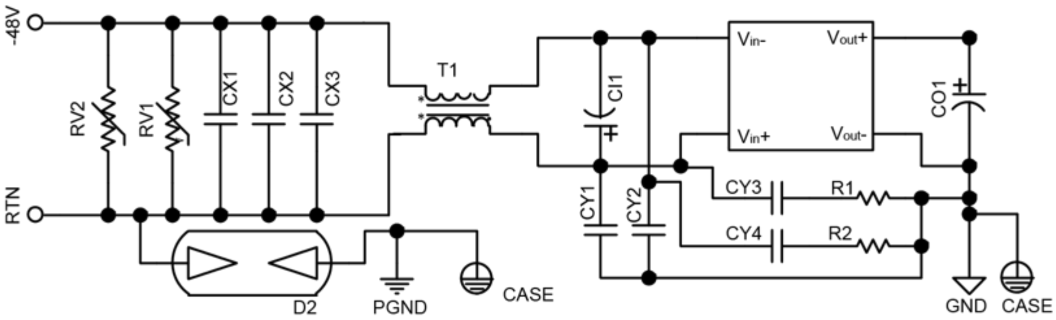
- When modules are connected in parallel, connect the SYNC pins of all the modules and connect the ISHARE pins. If one of the modules powers off or is faulty, disconnect its SYNC and ISHARE pins from the bus.
- The module cannot start up at CC load without SYNC.



11 Safety

11.1 EMC Specifications

Figure 11-1 EMC test set-up diagram



RV1, RV2: Varistor, 100 V, 4500 A

D2: Gas discharge tube, 90 V, 10 kA

CI1: Aluminum electrolytic capacitor, 100 V, 470 µF

CO1: SMD aluminum solid capacitor 660 µF

CX1, CX2, CX3: Metalized film capacitor, 1 µF, 275 V

CY1, CY2: Metalized film capacitor, 0.1 µF, 275 V

CY3, CY4: Chip multilayer ceramic capacitor, 22 nF, 1000 V

R1, R2: Chip thick film resistor, 1 W, 1Ω

T1: Common mode inductor, single phase, 400 µH

Table 11-1 EMC

Items	Standard	Specification
Conducted emission (CE)	DC Input	EN 55022, class A
Surge	Common mode 2 kV/differential mode 1 kV	IEC/EN 61000-4-5, criterion B
DC voltage dips, short interruption, variation	40%/70%/0%	IEC 61000-4-29, criterion B
	80%/120%	EN 61000-4-29, criterion A

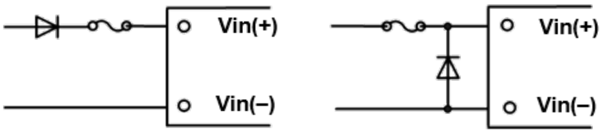
11.2 Recommended Fuse

The converter has no internal fuse. To meet safety requirements, a 35 A fuse is recommended.

11.3 Recommended Reverse Polarity Protection Circuit

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

Figure 11-2 Recommended reverse polarity protection circuits



11.4 Qualification Testing

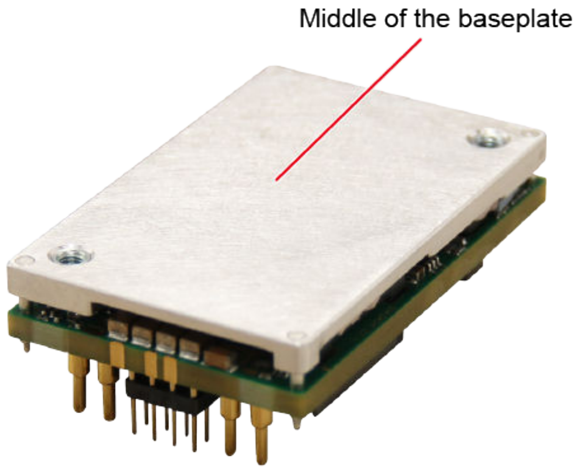
Parameter	Units	Condition
Highly accelerated life test (HALT)	6	Low temperature limit: –60°C; high temperature limit: 110°C; vibration limit: 40 G; temperature change rate: 40°C per minute; vibration frequency range: 10–10000 Hz; axes of vibration: X/Y/Z
Thermal shock	6	500 temperature cycles between –40°C and +125°C with the temperature change rate of 20°C per minute; lasting for 30 minutes both at –40°C and +125°C
Thermal humidity bias (THB)	16	Maximum input voltage; 85°C; 85% RH; 1000 operating hours under lowest load power
High temperature operation bias (HTOB)	16	Rated input voltage; ambient temperature between +45°C and +55°C; airflow rate = 0.5–5 m/s, 1000 operating hours; 50% to 80% load
Power and temperature cycling test (PTC)	32	Rated input voltage; ambient temperature between –40°C and +85°C; airflow rate = 0.5–5 m/s, 1000 operating hours; 50% load
Long life test	-	Ambient temperature between +30°C and +60°C; 50% to 80% load, T = 6 months

11.5 Thermal Consideration

Thermal Test Point

Decide proper airflow to be provided by measuring the temperature at the middle of the baseplate shown in **Figure 11-3** to protect the converter against overtemperature. The overtemperature protection threshold is obtained based on this thermal test point.

Figure 11-3 Thermal test point



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): $P_d = P_o(1-\eta)/\eta$.

11.6 MSL Rating

Store and transport the converter as required by the moisture sensitivity level (MSL) rating 1 specified in the IPC J-STD-020D/033C. The surface of a soldered converter must be clean and dry. Otherwise, the assembly, test, or even reliability of the converters will be negatively affected.

11.7 Mechanical Consideration

Installation

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

Soldering

The converter supports standard wave soldering and hand soldering. Reflow soldering is not allowed.

1. For wave soldering, the temperature on body is specified to maximum 260°C for maximum 7s.
2. For soldering by hand, the iron temperature should be maintained at 350°C to 420°C and applied to the converter pins for less than 10 seconds. Longer exposure can cause internal damage to the converter. Cleaning of solder joint can be performed with cleaning solvent IPA or similative.

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