GDC1K5D5023-PD DC-DC Converter

Technical Manual

Issue 1.0

Date 2020-11-25

HUAWEI TECHNOLOGIES CO., LTD.

About This Document

Purpose

This document describes the GDC1K5D5023-PD 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

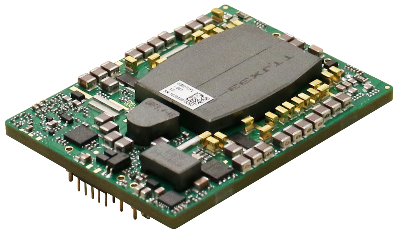
Changes between document issues are cumulative. The latest document issue contains all the changes made in earlier issues.

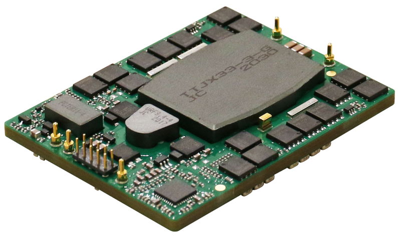
Issue 1.0 (2020-11-25)

This issue is the first release.

Contents

1 Product Overview





Product Description

The GDC1K5D5023-PD is a new generation non-isolated DC-DC converter that uses a non-industry nonstandard brick structure, featuring high efficiency and power density with low output ripple and noise. It operates from an input voltage range of 34 V to 72 V (The voltage should be larger than 36 V when the module is ready to work), and provides the rated output voltages of 23 V and 50 V as well as the rated output power of 1500 W.

Features

- Efficiency: 96% (V_{in} = 48 V, V_{out1} = 50 V, T_B = 25°C)
- Length x Width x Height: 64.8 mm x 50.0 mm x 9.7 mm (2.55 in. x 1.97 in. x 0.38 in.)
- Weight: 88 g
- Input undervoltage protection, output overcurrent protection (50 V, hiccup mode), output short-circuit protection (hiccup mode), output overvoltage protection (50 V, hiccup mode), overtemperature protection (self-recovery)
- PMBus communication
- UL certification
- UL 60950-1, UL 62368-1 and C22.2 No. 60950-1 compliant
- RoHS6 compliant

Model Naming Convention

GDC	1K5	D	5023	–	P	D
1	2	3	4		5	6

1 — 48 V input, high performance, digital control nonstandard brick

2 — Output power: 1500 W

3 — Double outputs

4 — Output voltage: 50 V and 23 V

5 — PMBus

6 — Version

Applications

Widely used in telecom, industrial, instrument monitoring, and test equipment applications

2 Electrical Specifications

2.1 Absolute Maximum Ratings

Table 2-1 Absolute maximum ratings

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
Input voltage ● Continuous ● Transient (100 ms)	 - -	 - -	 72 80	 V V	 - Allow reset, no damaged
Operating ambient temperature (T_A)	–40	-	85	°C	1. Module would trigger OTP in the ambient temperature of 85°C without radiator. 2. Module can meet all specifications of requirement before triggering OTP in the ambient temperature of 85°C.
Storage temperature	–40	-	125	°C	-
Operating humidity	5	-	95	% RH	Non-condensing
External voltage applied to PMBus port	-	-	3.6	V	-
Altitude	-	-	5000	m	When the altitude above 1800 m, T_C derating applies decreases by 1°C for each additional 220 m.

2.2 Input

Table 2-2 Input specifications

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
Operating input voltage	34	48	72	V	The voltage should be greater than 36 V when the converter is ready to work.
Maximum input RMS current	-	-	50	A	V_{in} = 34–72 V; 1. Constant current in FDD mode. Constant current, $I_{out} = I_{omax}$. 2. For details about the current in TDD mode, see **Figure 6-1**. 3. For details about the distance of remote power supply, see **Table 6-1**.
No-load loss	-	11	18	W	V_{in} = 36 V, V_{out1} = 50 V, I_{out1} = 0 A, V_{out2} = 20 V, I_{out2} = 0 A, T_B = 25°C
	-	11	18	W	V_{in} = 48 V, V_{out1} = 50 V, I_{out1} = 0 A, V_{out2} = 20 V, I_{out2} = 0 A, T_B = 25°C
	-	15	24	W	V_{in} = 63 V, V_{out1} = 50 V, I_{out1} = 0 A, V_{out2} = 20 V, I_{out2} = 0 A, T_B = 25°C
	-	22	30	W	V_{in} = 72 V, V_{out1} = 50 V, I_{out1} = 0 A, V_{out2} = 20 V, I_{out2} = 0 A, T_B = 25°C
Input capacitance	2000	-	-	µF	Aluminum electrolytic capacitor; constant current; ESR < 170 mΩ.

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
	3400	-	-	μF	Aluminum electrolytic capacitor; ESR < 54 mΩ. For 50 V output details, see Figure 6-1.

2.3 Output

Table 2-3 Output specifications

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
Output voltage setpoint	50 V	49.5	50.0	50.5	V	T_A = 25°C, V_{in} = 48 V; I_{out} = 50% I_{omax}
	23 V	18	20	22	V	
Output current	50 V	0	21	30	A	Constant current
		2.6	27	33	A	For 50 V output details, see Figure 6-1.
	23 V	0	0.22	0.27	A	Startup power: typical 4.5 W; maximum output power is not less than 5.5 W; V_{out1} need to ensure that V_{out2} can carry a typical power of 4.5 W for a long time, the maximum output power is not less than 5.5 W.
Output power	50 V	0	1050	1500	W	Constant current.
		130	1350	1650	W	For 50 V output details, see Figure 6-1.

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
	23 V	0	4.5	5.5	W	Startup power: typical 4.5 W; maximum output power is not less than 5.5 W; When V_{out1} is abnormal, V_{out2} should can carry a typical power of 4.5 W for a long time and the maximum output power is not less than 5.5 W.
Output line regulation	50 V	–1	-	1	%	V_{in} = 34–72 V; I_{out} = I_{onom}
	23 V	17	-	32	V	
Output load regulation	50 V	–1.5	-	1.5	%	V_{in} = 48 V; I_{out} = I_{omin} – I_{onom}
	23 V	17	-	32	V	
Regulated voltage precision	50 V	–3	-	3	%	V_{in} = 34–72 V; I_{out} = I_{omin} – I_{onom}
	23 V	17	-	32	V	
Cross regulated voltage precision	23 V	17	-	32	V	V_{in} = 48 V; I_{out} = I_{omin} – I_{onom}
Temperature coefficient	50 V	–0.02	-	0.02	%/°C	T_A = –40°C to +85°C
	23 V	17	-	32	V	
External capacitance	50 V	2000	-	3500	µF	• Aluminum electrolytic capacitor. • Constant current. • The ESR of 50 V output capacitors should be less than 80 mΩ. • 50 V output capacitors should contain at least 17.6 µF ceramic capacitor.

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
		2000	-	3500	µF	• Aluminum electrolytic capacitor. • 50 V output power for peak current. • The ESR of 50 V output capacitors should be less than 90 mΩ. • 50 V output capacitors should contain at least 17.6 µF ceramic capacitor. • For 50 V output details, see **Figure 6-1**.
	23 V	40	-	100	µF	-
Output ripple and noise (see **Note**)	50 V	-	-	500	mV	• Oscilloscope bandwidth: 20 MHz. • For equipment test. • The ESR of 50 V output capacitors should be less than 54 mΩ. • 50 V output capacitors should contain at least 17.6 µF ceramic capacitor. • Temperature of capacitor > –20°C.
	23 V	-	-	400	mV	• Oscilloscope bandwidth: 20 MHz. • For equipment test. • Temperature of capacitor > –20°C.

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
Output voltage adjustment	50 V	34	-	55	V	Adjusted through the PMBus port.
Output voltage overshoot	50 V	-	-	5	%	Full ranges of V_{in}, I_{out} and T_A.
	23 V	-	-	33	V	
Output voltage delay time	50 V	1000	-	5000	ms	-
	23 V	-	-	200	ms	
Output voltage rise time	50 V	-	-	200	ms	From 10% V_{out} to 90% V_{out}.
	23 V	-	-	50	ms	
Switching frequency	50 V	-	250	-	kHz	Buck-boost circuit switching frequency.
	23 V	-	400	-	kHz	Auxiliary power supply switching frequency.

NOTE

- During the equipment test (T_A = 25°C, V_{out1} = 50 V/V_{out2} = 23 V), the layout distance of minimum capacitor can be extended to less than 15 cm.

2.4 Efficiency

Table 2-4 Efficiency specifications

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
Load (I_{out1} = 21 A)	95.0	96.0	-	%	V_{in} = 48 V; V_{out1} = 50 V; T_B = 25°C
Load (I_{out1} = 30 A)	94.5	95.5	-	%	
Load (I_{out1} = 21 A)	95.0	96.0	-	%	V_{in} = 36 V; V_{out1} = 50 V; T_B = 25°C
Load (I_{out1} = 30 A)	94.5	95.5	-	%	
Load (I_{out1} = 21 A)	95.0	96.0	-	%	V_{in} = 63 V; V_{out1} = 50 V; T_B = 25°C
Load (I_{out1} = 30 A)	94.0	95.0	-	%	
Load (I_{out1} = 21 A)	95.0	96.0	-	%	V_{in} = 72 V; V_{out1} = 50 V; T_B = 25°C
Load (I_{out1} = 30 A)	94.0	95.0	-	%	

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
Load (I_{out1} = 3 A)	89.0	90.0	-	%	V_{in} = 48 V; V_{out1} = 50 V; T_B = 25°C

2.5 Protection

Table 2-5 Input protection

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
Input undervoltage protection threshold	50 V	30.5	32	33.5	V	The 23 V power supply may rebounds when the input power is shut down.
	23 V	16	19	23	V	
Input undervoltage recovery threshold	50 V	32.5	34	35.5	V	
	23 V	19	22	26	V	
Input undervoltage protection hysteresis	50 V	1.5	2.5	3.5	V	
	23 V	-	3	-	V	

Table 2-6 Output protection

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
Output overvoltage protection	50 V	60	-	65	V	Hiccup mode
Output short-circuit protection	50 V	-	-	-	-	Hiccup mode. The converter supports continuous short circuit. The output current rise slope must ≤ 0.2 A/μs.
	23 V	-	-	-	-	

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
Output overcurrent protection	50 V	36	-	45	A	Hiccup mode. • If output voltage < 50 V, the duration time of output voltage drop to 90% V_{out} is at least 10 ms for 50 V output overcurrent protection. • The output current rise slope must ≤ 0.2 A/μs.
	23 V	-	-	-	A	-
Overtemperature protection threshold	50 V	110	120	130	°C	Self-recovery. The overtemperature protection hysteresis is obtained by measuring the temperature of the PCB near the temperature sensor IC.
Overtemperature protection hysteresis	50 V	5	-	-	°C	

2.6 Dynamic Characteristics

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
Overshoot amplitude	50 V	-	-	2500	mV	Current change rate: 1 A/μs T = 2 ms Load: 25%–50%–25%, 50%–75%–50%
Recovery time		-	-	-	μs	
Overshoot amplitude		-	-	5000	mV	Current change rate: 0.1 A/μs T = 2 ms Load: 10%–90%–10%
Recovery time		-	-	1000	μs	

Parameter	Output	Minimum	Typical	Maximum	Unit	Notes & Conditions
Overshoot amplitude (FDD)	50 V	-	-	2500	mV	Current change rate: 10 A/µs T = 100 µs Load: 2280 W–950 W–2280 W The output power of 50 V reaches 2280 W in dynamic mode of 20 µs, and 950 W for the left 80 µs. Tested with an FDD system. Larger than 80% load step, there is no special standard. The module should be cooperated with RRU.
Recovery time (FDD)		-	-	100	µs	
Overshoot amplitude (TDD)	50 V	-	-	5000	mV	Current change rate: 1 A/µs V_{out} = V_{onom}, T = 10 ms/5 ms/2.5 ms Load: 130 W–1650 W–130 W The output power of 50 V reaches 1650 W in dynamic mode of 7.5 ms/3.75 ms/1.875 ms, and 130 W for the left 2.5 ms/1.25 ms/0.625 ms. Tested with a TDD system. Larger than 80% load step, there is no special standard. The module should be cooperated with RRU.
Recovery time (TDD)		-	-	-	µs	

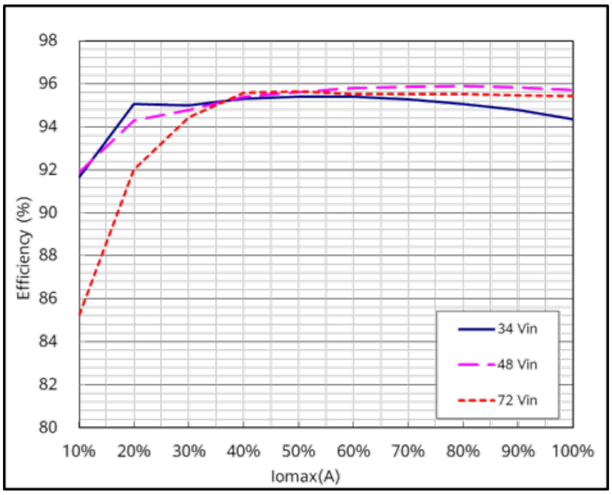
2.7 Other Characteristics

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
N12V_FAULT voltage (low level)	0	-	0.8	V	Low level effective. High level in normal mode; low level in abnormal mode. The duration must be greater than 200 µs.
N12V_FAULT voltage (high level)	2.8	-	3.6	V	
N12V_FAULT current (low level)	–4	-	-	mA	-
N12V_FAULT current (high level)	-	-	4	mA	-
PWR_I2C_RESET voltage (low level)	0	-	0.8	V	High level effective. The duration must be greater than 700 ms. 10 kΩ resistor connected to the ground.
PWR_I2C_RESET voltage (high level)	2.8	-	3.6	V	
PWR_I2C_RESET current (low level)	–4	-	-	mA	-
PWR_I2C_RESET current (high level)	-	-	4	mA	-
REMOTE_POWER_OFF voltage (low level)	0	-	0.8	V	High level effective (all output should be reset). The duration must be greater than 150 ms. 50 V output should be kept at low level for at least 200 ms before restart. 10 kΩ resistor connected to the ground.
REMOTE_POWER_OFF voltage (high level)	2.8	-	3.6	V	
REMOTE_POWER_OFF current (low level)	–4	-	-	mA	-

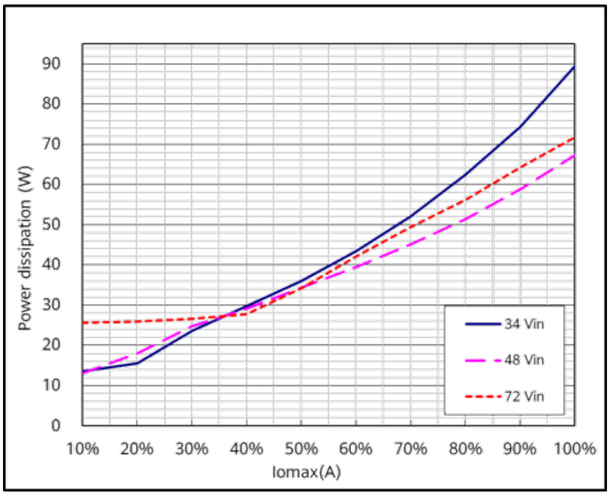
<table>
<tr><th>Parameter</th><th>Minimum</th><th>Typical</th><th>Maximum</th><th>Unit</th><th>Notes & Conditions</th></tr>
<tr><td>REMOTE_POWER_OFF current
(high level)</td><td>-</td><td>-</td><td>4</td><td>mA</td><td>-</td></tr>
<tr><td>PWR_ALARM current
(low level)</td><td>–4</td><td>-</td><td>-</td><td>mA</td><td>-</td></tr>
<tr><td>PWR_ALARM current
(high level)</td><td>-</td><td>-</td><td>4</td><td>mA</td><td>-</td></tr>
<tr><td>PWR_ALARM voltage
(low level)</td><td>0</td><td>-</td><td>0.8</td><td>V</td><td rowspan="2">• High level: normal; low level: abnormal.
• The alarm voltage can be only erased by PMBus command (0x03).
• Open drain output.
• Effective faults include:
– Overcurrent or short circuit of 50 V output.
– Overtemperature of 50 V output.
– Overvoltage of 50 V output.
– Input undervoltage.
– N12V_FAULT low level.</td></tr>
<tr><td>PWR_ALARM voltage
(high level)</td><td>2.8</td><td>-</td><td>3.6</td><td>V</td></tr>
</table>

3 Characteristic Curves

Conditions: T_A = 25°C unless otherwise specified.



Efficiency curve



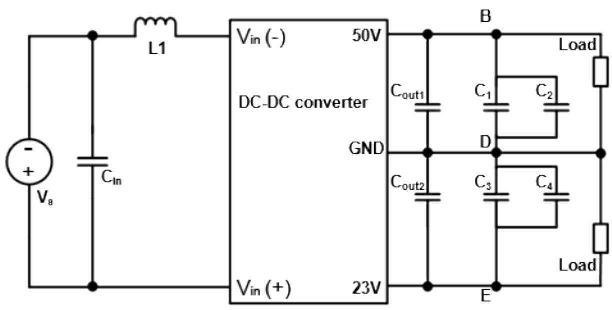
Power dissipation curve

4 Typical Waveforms

NOTE

- The converter should cooperate with a system. It is recommended that the input inductor whose inductance is at least 1 µH be added after the input capacitor.
- Points B and D as well as D and E are used for testing the output voltage ripple.

Figure 4-1 Test setup diagram



C_{in}:

FDD mode, ESR < 170 mΩ: The 2000 µF aluminum electrolytic capacitor is recommended.

TDD mode, ESR < 54 mΩ: The 3400 µF aluminum electrolytic capacitor is recommended.

C_{out1}:

FDD mode, ESR < 80 mΩ: The 2000 µF aluminum capacitor is recommended.

TDD mode, ESR < 90 mΩ: The 2000 µF aluminum capacitor is recommended.

In addition to the output capacitor, at least 17.6 µF ceramic capacitor should be added to the output capacitor.

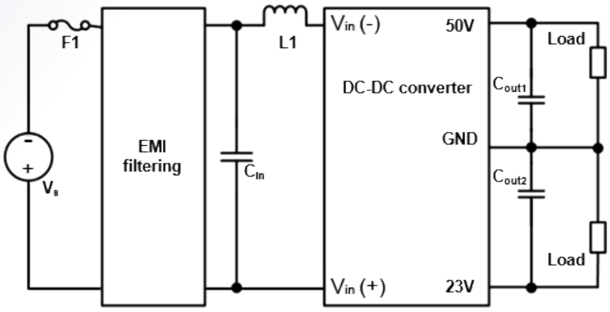
C_{out2}: The 40 µF ceramic capacitor is recommended.

C_1, C_3: The 0.1 µF ceramic capacitor is recommended.

C_2, C_4: The 10 µF aluminum electrolytic capacitor is recommended.

L_1: Inductor, 1 µH.

Figure 4-2 Typical application circuit



F_1: 70 A fuse (fast-blow).

C_{in}:

FDD mode, ESR < 170 mΩ: The 2000 µF aluminum electrolytic capacitor is recommended.

TDD mode, ESR < 54 mΩ: The 3400 µF aluminum electrolytic capacitor is recommended.

C_{out1}:

FDD mode, ESR < 80 mΩ: The 2000 µF aluminum capacitor is recommended.

TDD mode, ESR < 90 mΩ: The 2000 µF aluminum capacitor is recommended.

In addition to the output capacitor, at least 17.6 µF ceramic capacitor should be added to the output capacitor.

C_{out2}: The 40 µF ceramic capacitor is recommended.

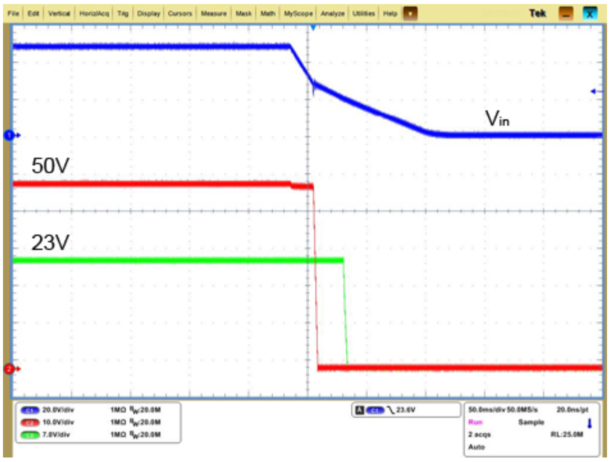
L_1: Inductor, 1 µH.

4.1 Power-On/Power-Off

Conditions: T_A = 25°C unless otherwise specified.

Startup by power-on

(V_{in} = 48 V, V_{out1} = 50 V, V_{out2} = 23 V)

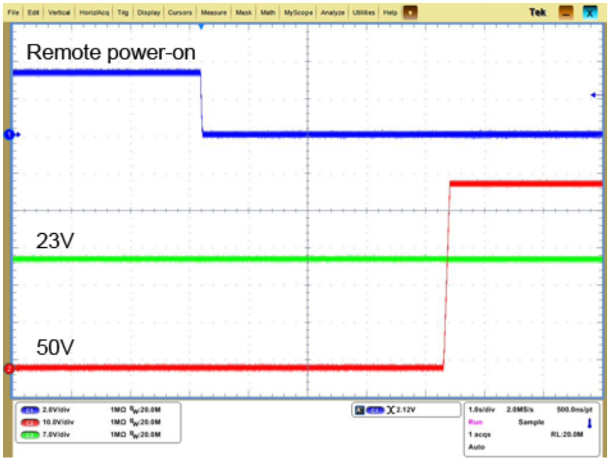


Shutdown by power-off

(V_{in} = 48 V, V_{out1} = 50 V, V_{out2} = 23 V)

4.2 Remote Power-On/Power-Off

Conditions: T_A = 25°C unless otherwise specified.

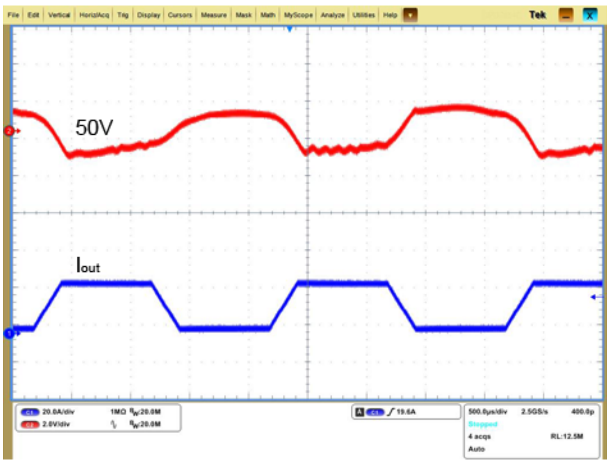


Remote power-on
(V_{in} = 48 V, V_{out1} = 50 V, V_{out2} = 23 V)

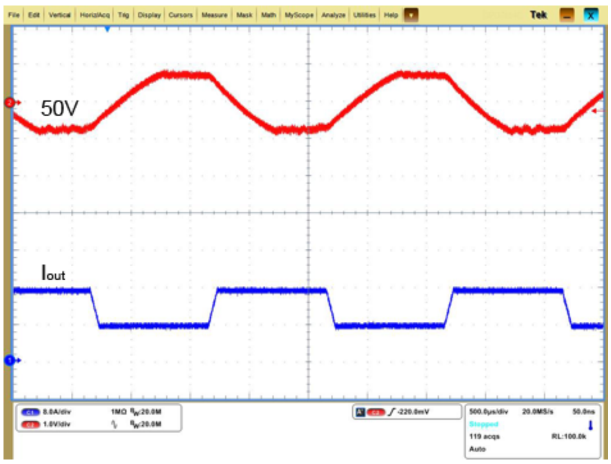
Remote power-off
(V_{in} = 48 V, V_{out1} = 50 V, V_{out2} = 23 V)

4.3 Output Voltage Dynamic Response

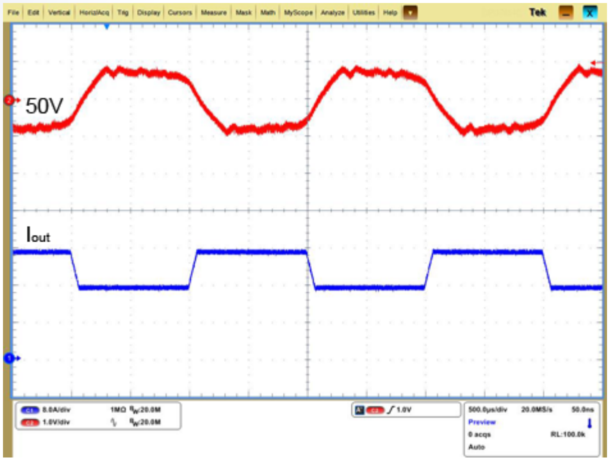
Conditions: T_A = 25°C unless otherwise specified.



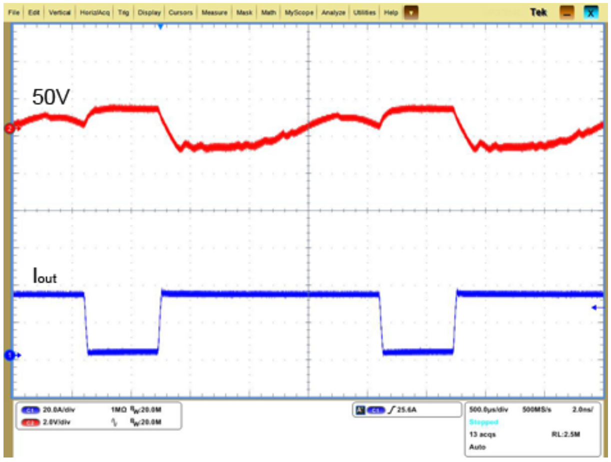
Output voltage dynamic response
(V_{in} = 48 V; load: 10%–90%–10%;
di/dt = 0.1 A/μs; T = 2 ms)



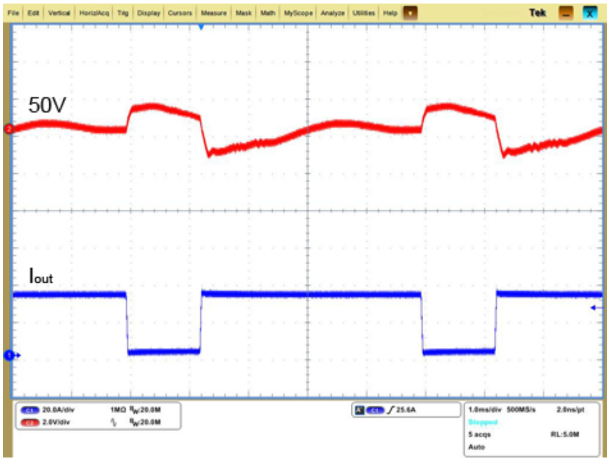
Output voltage dynamic response
(V_{in} = 48 V; load: 25%–50%–25%;
di/dt = 1 A/μs; T = 2 ms)



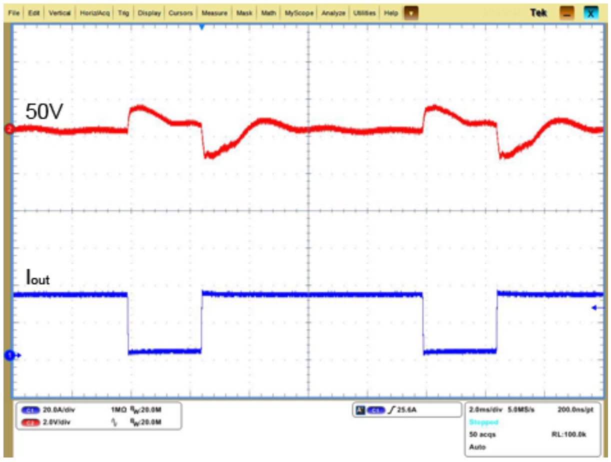
Output voltage dynamic response
(V_{in} = 48 V; load: 50%–75%–50%;
di/dt = 1 A/μs; T = 2 ms)



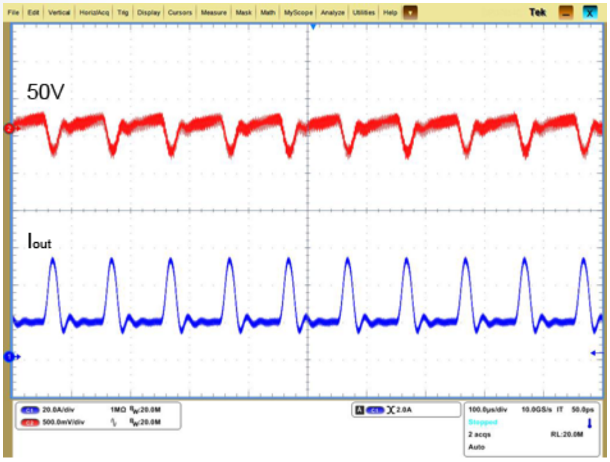
Output voltage dynamic response (TDD)
(V_{in} = 48 V; load = 130 W–1650 W–130 W;
di/dt = 1 A/μs; T = 2.5 ms; V_{out1} = 50 V)



Output voltage dynamic response (TDD)
(V_{in} = 48 V; load = 130 W–1650 W–130 W;
di/dt = 1 A/μs; T = 5 ms; V_{out1} = 50 V)



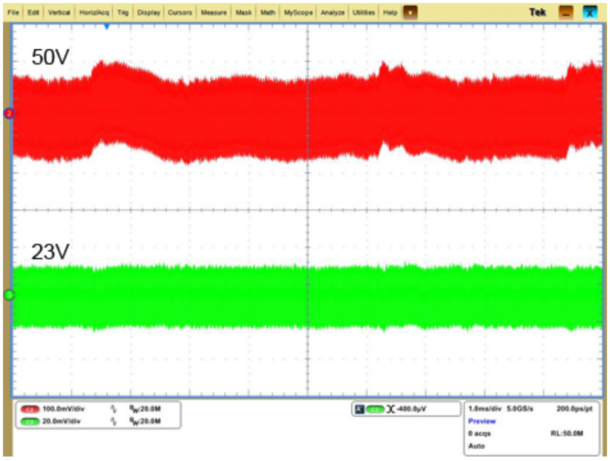
Output voltage dynamic response (TDD)
(V_{in} = 48 V; load = 130 W–1650 W–130 W;
di/dt = 1 A/μs; T = 10 ms; V_{out1} = 50 V)



Output voltage dynamic response (FDD)
(V_{in} = 48 V; load = 2280 W–950 W–2280 W; di/dt = 10 A/μs; T = 100 μs; V_{out} = 50 V)

4.4 Output Voltage Ripple

Conditions: T_A = 25°C unless otherwise specified.



Output voltage ripple
(For points B and D, D and E in the test setup diagram, V_{in} = 48 V; V_{out1} = 50 V, V_{out2} = 23 V, 100% load)

5 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.

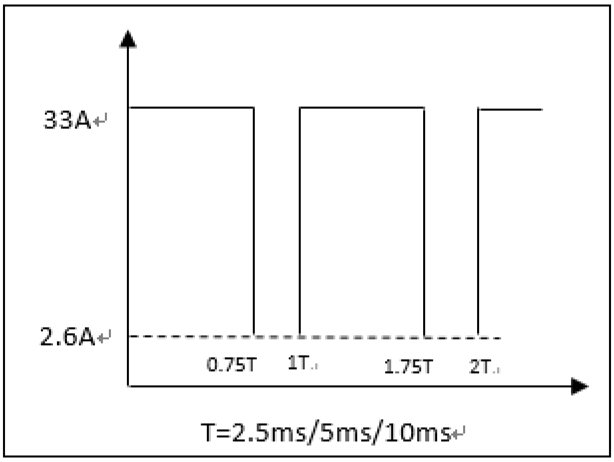
- **Overtemperature Protection**

  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.

6 Long-Distance Input Power Supply

The converter supports long-distance power supply, and its output power is 1500 W. Figure 6-1 shows the peak current of the 50 V output in TDD mode.

Figure 6-1 Peak current of the 50 V output



The following table lists the recommended cable cross-sectional area, cable length, and minimum input voltage in the long-distance power supply solution in TDD and FDD modes.

Table 6-1 Long-distance input power supply

Cable Cross-Sectional Area (mm^2)	Maximum Cable Length (m)	Minimum Input Voltage (V)	Working Mode
8.2	70	53.5	FDD
8.2	40	63.0	FDD
8.2	70	53.5	TDD
8.2	50	63.0	TDD

7 Communication

7.1 Signal Specifications

Table 7-1 PMBus signal interface characteristics

Parameter	Minimum	Typical	Maximum	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} = –13 mA
Logic output high (V_{OH})	2.4	-	3.6	V	I_{OH} = 10 mA
PMBus setup time (T_{set})	250	-	-	ns	For details about the values of T_{set} and T_{hold}, see **7.2.3 Data Transmission Mode**.
PMBus hold-up time (T_{hold})	300	-	-	ns	
PMBus address	-	-	-	V	The PMBus address distinguishes the working mode (TDD/FDD) of the converter.

Table 7-2 PMBus detection precision (for 50 V output)

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
Input voltage detection precision	–2	-	2	V	V_{in} = 34–72 V; T_A = –40°C to +85°C
Output voltage detection precision	–1.5	-	1.5	V	
Output current detection precision	–2	-	2	A	

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
Temperature detection precision	–5	-	5	°C	V_{in} = 34–72 V; I_{out} = I_{omax}; T_A = –40°C to +125°C

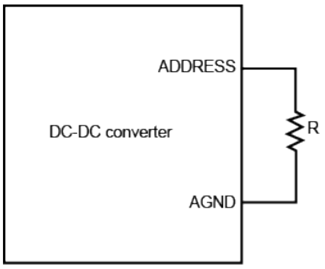
7.2 Data Link Layer Protocol

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*.

7.2.1 Converter Address Detection

The converter supports external configuration of the PMBus address. The default address is 91. The converter does not support changing the address resistance during operation but supports only one detection prior to each startup. The address selection resistor should be deployed in the secondary area. The converter working mode (FDD/TDD) is identified by address, as shown in Figure 7-1.

Figure 7-1 Converter address detection



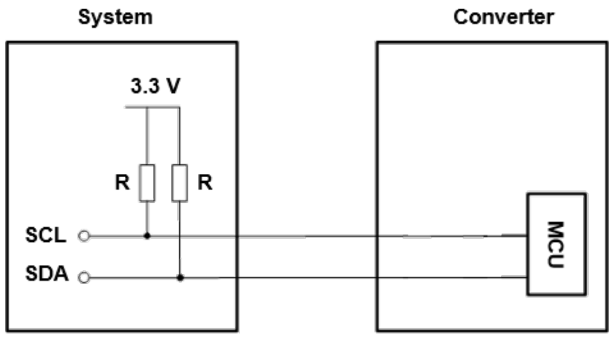
The following table lists the mapping between voltage and converter address.

Resistance (kΩ)	Pin Voltage (V)	Address (Decimal)	Working Mode
0–15	0–0.165	84	TDD
22	0.198–0.242	85	TDD
30	0.270–0.330	86	TDD
51	0.459–0.561	87	TDD
80.6	0.725–0.887	88	FDD
113	1.017–1.243	89	FDD
150	1.350–1.650	90	FDD
Left open	1.980–2.500	91	FDD

7.2.2 SCL and SDA

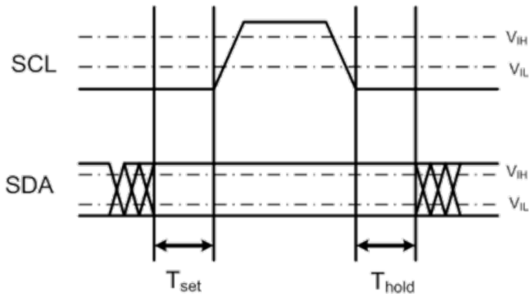
The SCL and SDA are each connected to a pull-up resistor and connected to the communication bus through the fault isolation circuit. Figure 7-2 shows the interconnect diagram of SCL and SDA.

Figure 7-2 Interconnect diagram of SCL and SDA



7.2.3 Data Transmission Mode

The converter supports both 100 kHz (default) and 400 kHz clock rates. 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.



7.3 Network Layer Protocol

7.3.1 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.

7.3.2 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.

7.3.3 Data Transmission

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

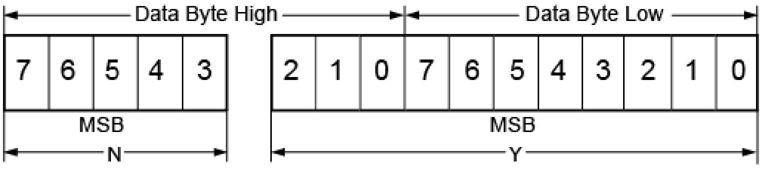
7.4 Application Layer Protocol

7.4.1 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 7-3 Linear 11 data format



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

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

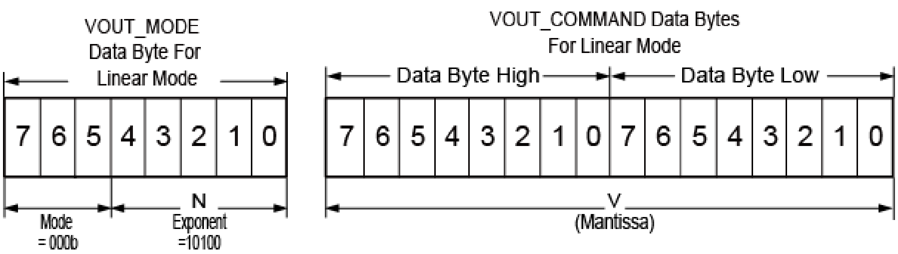
Where:

- 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 7-4 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

7.4.2 Commands

Hex Code	Command Name	Data Type	Data Format
0x00	PAGE	Read Byte	Unsigned
0x01	OPERATION	Read/Write Word	Unsigned
0x03	CLEAR_FAULTS	Sent Byte	-
0x11	STORE_DEFAULT_ALL	Sent Byte	-
0x20	VOUT_MODE	Read Byte	Unsigned
0x21	VOUT_COMMAND	Read/Write Word	Linear 16 Q9
0x78	STATUS_BYTE	Read Byte	Unsigned
0x79	STATUS_WORD	Read Word	Unsigned
0x7A	STATUS_VOUT	Read Byte	Unsigned
0x7B	STATUS_IOUT	Read Byte	Unsigned
0x7C	STATUS_INPUT	Read Byte	Unsigned
0x7D	STATUS_TEMPERATURE	Read Byte	Unsigned
0x80	MFR_SPECIFIC	Read Byte	Unsigned
0x88	READ_VIN	Read Word	Linear 11
0x89	READ_IIN	Read Word	Linear 11
0x8B	READ_VOUT	Read Word	Linear 16 Q9
0x8C	READ_IOUT	Read Word	Linear 11
0x8D	READ_TEMPERATURE1	Read Word	Linear 11
0x8E	READ_TEMPERATURE2	Read Word	Linear 11
0xEA	rw_bbox_frame_id	Read/Write Word	Unsigned
0xEB	read_bbox_frame_data	Read Block	Unsigned
0xEC	bbox_sys_time	Read/Write Block	Unsigned

Hex Code	Command Name	Data Type	Data Format
0xEF	read_bbox_frame_num	Read Word	Unsigned
0xF3	SOFTWARE_VERSION	Read Word	Unsigned
0xF7	SOFTWARE_VERSION_2	Read Word	Unsigned
0xFB	SOFTLOAD_INFO	Read Block	ASCII
0xFC	SOFTLOAD_CTRL	Read/Write Word	Unsigned
0xFD	MFR_DEVICE_ID	Write Block	Write: Unsigned

7.4.3 Command Descriptions

STATUS_WORD (0x79)

Data	Status
Bit 15	VOUT
Bit 14	IOUT
Bit 13	INPUT
Bit 12	MFR
Bit 11	POWER_GOOD
Bit 10	COOLING
Bit 9	Reserved
Bit 8	FAILURE
Bit 7	Reserved
Bit 6	OFF
Bit 5	VOUT_OV
Bit 4	IOUT_OC
Bit 3	VIN_UV
Bit 2	TEMPERATURE
Bit 1	CML
Bit 0	HIGH_BYTE

STATUS_VOUT (0x7A)

Data	Status
Bit 7	OV_FAULT
Bit 6	OV_WARN
Bit 5	UV_WARN
Bit 4	UV_FAULT
Bit 3	Reserved
Bit 2	Reserved
Bit 1	Reserved
Bit 0	Reserved

STATUS_IOUT (0x7B)

Data	Status
Bit 7	OC_FAULT
Bit 6	Reserved
Bit 5	OC_WARN
Bit 4	Reserved
Bit 3	Reserved
Bit 2	Reserved
Bit 1	OP_FAULT
Bit 0	OP_WARNING

STATUS_INPUT (0x7C)

Data	Status
Bit 7	Reserved
Bit 6	OV_WARN
Bit 5	UV_WARN
Bit 4	UV_FAULT

Data	Status
Bit 3	Reserved
Bit 2	Reserved
Bit 1	Reserved
Bit 0	Reserved

STATUS_TEMPERATURE (0x7D)

Data	Status
Bit 7	OT_FAULT
Bit 6	OT_WARNING
Bit 5	Reserved
Bit 4	UT_FAULT
Bit 3	OT_FAULT2
Bit 2	OT_FAULT3
Bit 1	Reserved
Bit 0	Reserved

STATUS_CML (0x7E)

Data	Status
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

MFR_SPECIFIC (0x80)

Data	Status
Bit 7	VOUT_FB
Bit 6	DYN_OCP
Bit 5	FAST_OCP
Bit 4	PEAK_OCP
Bit 3	I2C_RESET
Bit 2	FAST_OVIN
Bit 1	N12V_OFF_LINE
Bit 0	VCC_UV

8 Mechanical Overview

Figure 8-1 Mechanical overview

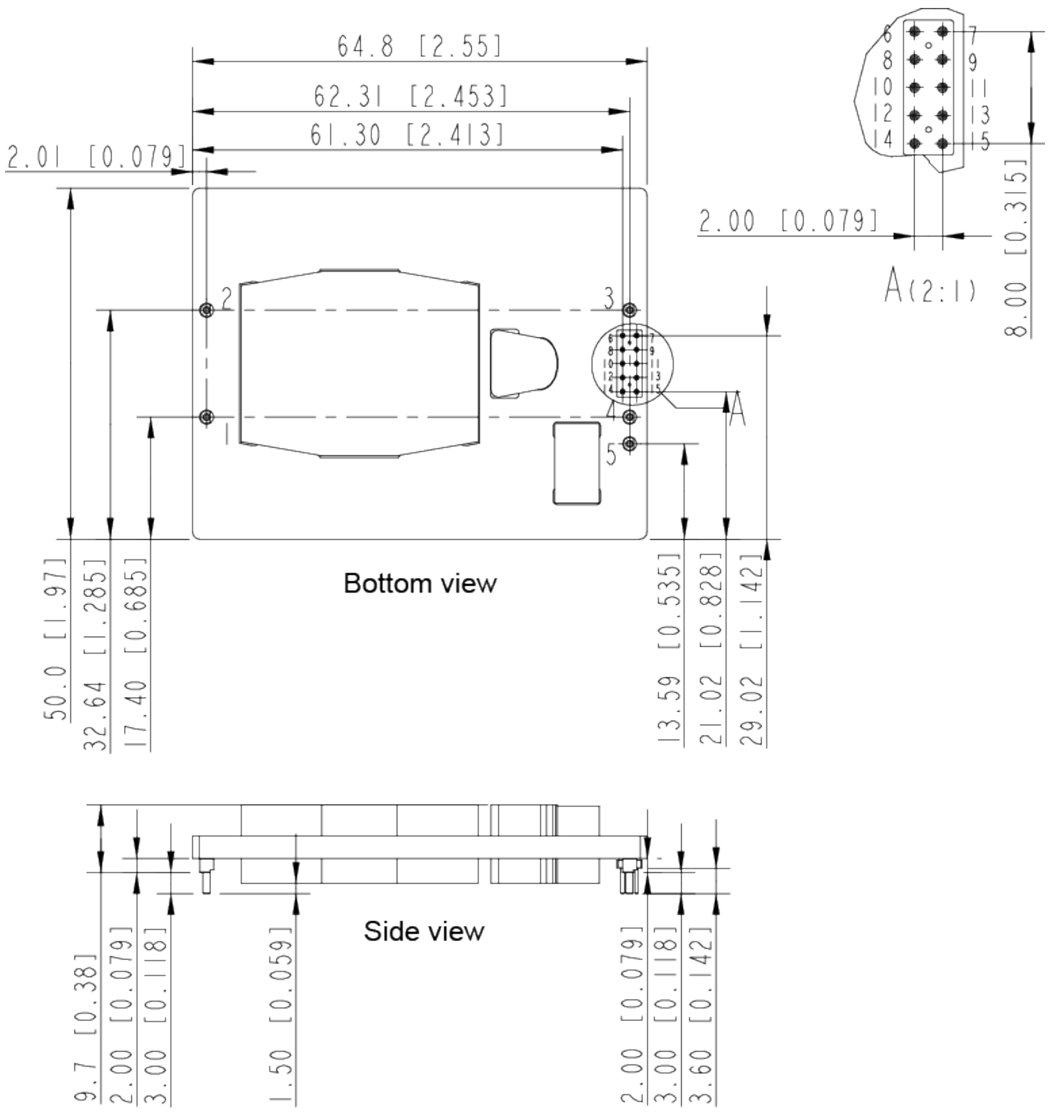


Table 8-1 Pin description

Pin No.	Pin name	Pin No.	Pin name	Pin No.	Pin name
1	V_{in} (+)	6	REMOTE_POWER_OFF	11	NC
2	V_{in} (–)	7	N12V_FAULT	12	PWR_ALARM
3	GND	8	23 V	13	PWR_I2C_RESET
4	50 V	9	AGND	14	PM_SCL
5	NC	10	ADDRESS (see **Note**)	15	PM_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. Pins 1–5 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. Pins 6–15 are 0.50 ± 0.05 mm [0.020 ± 0.002 in.] diameter.
3. Pin address is not used. It's default PMBus address is 0x5B.

9 Safety

Reliability Characteristics

Parameter	Minimum	Typical	Maximum	Unit	Notes & Conditions
Mean time between failures (MTBF)	-	2.5	-	Million hours	Telcordia SR332 Method 1 Case 3; 80% load; T_A = 40°C; normal input/ rated output; airflow rate = 1.5 m/s (300 LFM).

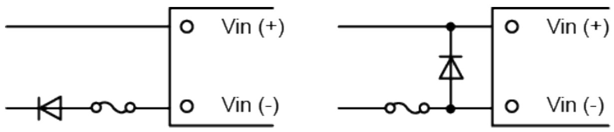
Recommended Fuse

The converter has no internal fuse. To meet safety requirements, a 70 A fuse is recommended.

Recommended Reverse Polarity Protection Circuit

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

Figure 9-1 Recommended reverse polarity protection circuit



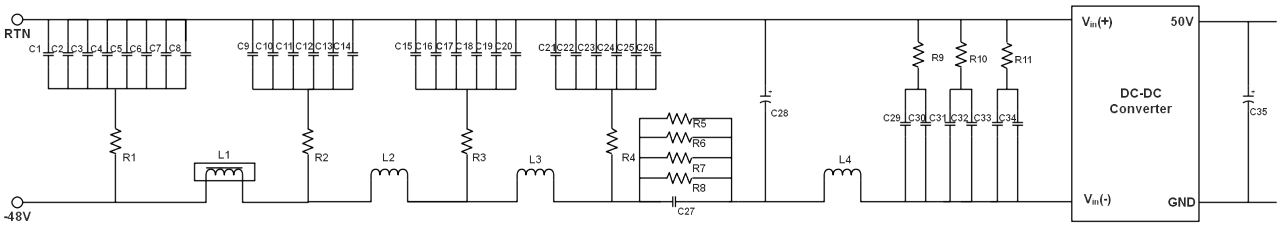
Qualification Testing

Item	Conditions
High accelerated life test	Low temperature limit: –60°C; high temperature limit: 110°C; random vibration limit: 40 G; temperature slope: 40°C per minute; vibration frequency range: 10 Hz–10000 Hz; axes of vibration: X/Y/Z.
Thermal cycling test (unpower)	Low temperature limit: –40°C; high temperature limit: 125°C; temperature dwell Time: 30 mins, temperature change rate: 5°C–20°C per minute, cycles: 700 cycles.

Item	Conditions
Thermal humidity bias	High temperature limit: 85°C; humidity: 85%, maximum input voltage; output: 50%–80% full load, air flow: 0.5–5m/s; 1000 operating hours
High temperature operation bias	Operating temperature: 45°C–55°C, rated input voltage; output: 50%–80% full load, airflow rate: 0.5 m/s (100 LFM) to 5 m/s (1000 LFM); 1000 operating hours.
Power and temperature cycling test	Rated input voltage; ambient temperature between –40°C and +85°C; temperature change rate: 10–15°C/min, output: 20%–50% full load, power cycles: 1000 cycles.

EMC Specifications

Figure 9-2 EMC test setup diagram



C1-C7	SMD ceramic capacitor, 1000 V, 22 nF
C8	SMD ceramic capacitor, 1000 V, 1 nF
C9-C26, C29-C34	SMD ceramic capacitor, 100 V, 2.2 µF
C27	Chip multilayer ceramic capacitor, 16 V, 0.1 µF
C28	Aluminium capacitor (FDD mode , ESR < 170 mΩ, 80 V, 2000 µF) Aluminium capacitor (TDD mode, ESR < 54 mΩ, 80 V, 3400 µF)
C35	Aluminum capacitor (FDD mode, ESR < 80 mΩ, 63 V, 2000 µF) Aluminum capacitor (TDD mode, ESR < 90 mΩ, 63 V, 2000 µF)
R1	Chip thick film resistor, 2 W, 68 mΩ

R2, R3, R4	Chip thick film resistor, 1 W, 20 mΩ
R5, R6, R7, R8	Chip thick film resistor, 1 W, 5 mΩ
R9, R10, R11	Chip thick film resistor, 1 W, 20 mΩ
L1	SMT inductor, 7 µH
L2, L3, L4	SMT inductor, 1.4 µH

Table 9-1 EMC specifications

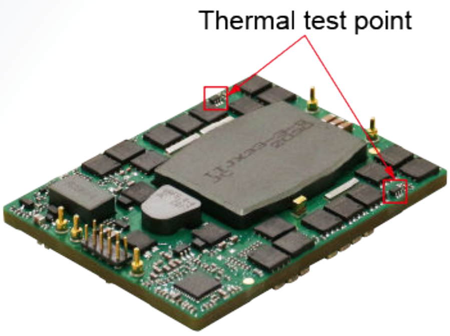
Parameter	Conditions	Criterion
Conducted emission (CE)	ClSPR 22	Criterion B
CS	0.15–80 MHz, 10 V [80% AM (1 kHz)]	IEC 61000-4-6, criterion A
DIP	40%/70%/0%	IEC 61000-4-29, criterion B
	80%/120%	IEC 61000-4-29, criterion A
EFT/B	2 kV	IEC 61000-4-4, criterion B
Protection against lightning	Polarity: positive/negative, 5 times Common mode: 20 kA (8/20 µs) Differential mode: 10 kA (8/20 µs), 6 kA (16/40 µs)	-
ESD	8 kV	IEC 61000-4-2, criterion B
Surge	2 kV/4 kV	IEC 61000-4-5, criterion B

Thermal Consideration

Thermal Test Point

Decide proper airflow to be provided by measuring the temperature of the thermal test point shown in **Figure 9-3** to protect the converter against overtemperature. The overtemperature protection threshold is obtained based on thermal test point.

Figure 9-3 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 (ŋ), and output power (P_o): $P_d = P_o (1 – ŋ)/ŋ$.

MSL Rating

Store and transport the converter as required by the moisture sensitivity level (MSL) rating 3 specified in the J-STD-020/033C. The surface of a soldered converter must be clean and dry. Otherwise, the assembly, test, or even reliability of the converter will be negatively affected.

Mechanical Consideration

Installation

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

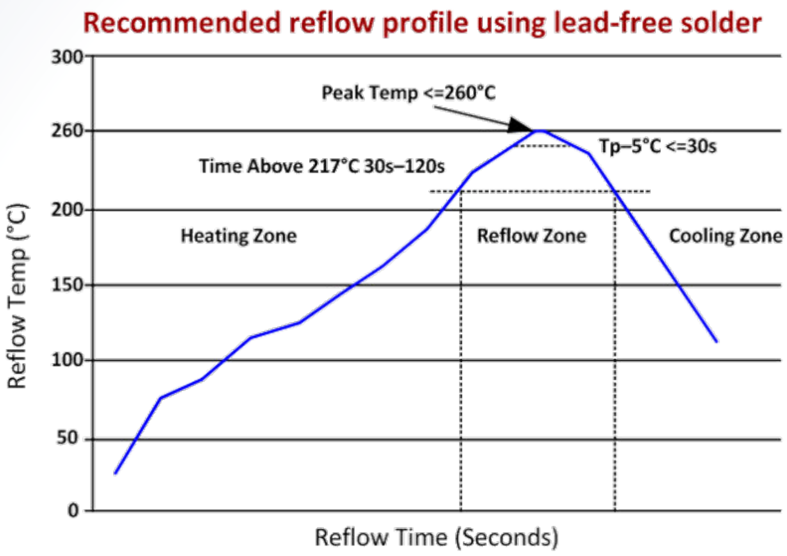
Soldering

The converter supports standard wave soldering, reflow soldering, and hand soldering.

- For wave soldering, the converter pins can be soldered at 260°C for less than 7 seconds.
- For reflow soldering, the converter pins can be soldered at 260°C.
- For hand soldering, the iron temperature should be maintained at 350°C to 420°C and applied to the converter pins for less than 10 seconds.

The converter can be rinsed using the isopropyl alcohol (IPA) solvent or other proper solvents.

Figure 9-4 Recommended reflow profile using lead-free solder



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