GDC45S54BP-P
DC-DC Converter Technical Manual V1.1

Nonstandard-Brick DC-DC Converter	–72 V to –38 V Input	–54 V Output Voltage	44.5 A Output Current	Positive Logic

Description

The GDC45S54BP-P is a new generation isolated DC-DC converter that uses an industry nonstandard-brick structure, featuring high efficiency and power density with low output ripple and noise. It operates from an input voltage range of –72 V to –38 V, and provides a rated output voltage of –54 V, the maximum output current of 44.5 A, and a rated output power of 2400 W.

GDC45S54BP-P

Operational Features

- Input voltage: –72 V to –38 V
- Maximum output current: 44.5 A
- Efficiency: 98.5% (V_{in} = –53 V, V_{out} = –54 V, 50% load)

Mechanical Features

- Industry nonstandard-brick (L x W x H): 70.00 x 45.00 x 12.70 mm (2.756 x 1.772 x 0.500 in.)
- Weight: 98 g

Control Features

- Remote On/Off
- PMBus control

Protection Features

- Input undervoltage protection
- Output overcurrent protection (constant current mode, self-recovery)
- Output short circuit protection (constant current mode, self-recovery)
- Output overvoltage protection (latch-off)
- Overtemperature protection (self-recovery)

Safety Features

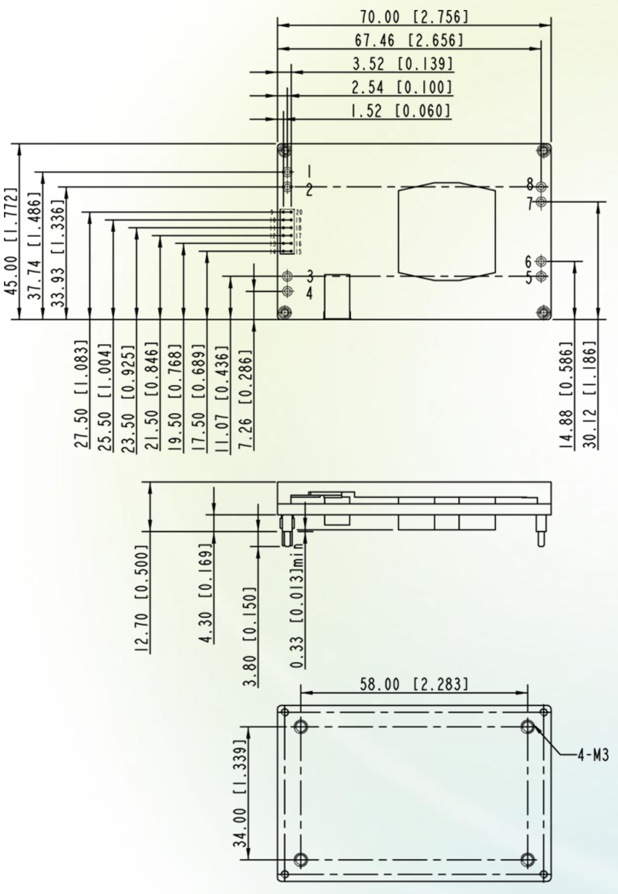
- UL and CE certification and CB report available
- UL60950-1, C22.2 No. 60950-1, EN60950-1 and IEC 60950-1 compliant
- RoHS6 compliant

Model Naming Convention

GDC	45	S	54	B	P	-	P
1	2	3	4	5	6		7

1 — 48 V input, high performance, digital control nonstandard brick
2 — Output current: 44.5 A
3 — Single output
4 — Output voltage: –54 V
5 — With a baseplate
6 — Positive logic
7 — PMBus

Mechanical Diagram



Pin Description

Pin No.	Function	Pin No.	Function
1	V_{in} (–)	11	CS_LOAD
2	V_{in} (–)	12	CB
3	V_{in} (+)	13	LOADFB
4	V_{in} (+)	14	CNT
5	V_{out} (+)	15	AUX_12V
6	V_{out} (+)	16	ALERT
7	V_{out} (–)	17	SDA
8	V_{out} (–)	18	SCL
9	AUX_3V3	19	ADDR
10	CS_PWM	20	COM

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 1–8 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.

Electrical Specifications

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Absolute maximum ratings					
Input voltage Continuous Transient (≤ 100 ms)	 –80 –100	 - -	 - -	 V V	When the input voltage is in the range of –80 V to –73 V, the converter must not be damaged.
Ambient operating temperature (T_A)	–40	-	85	°C	Forced air cooling. See Figure 3 to Figure 6
Storage temperature	–40	-	125	°C	-
Operating humidity	5	-	95	% RH	Non-condensing
External voltage applied to SCL, SDA, CNT, ADDR, AUX_3V3, CB, LOADFB, CS_LOAD, or CS_PWM	0	-	3.6	V	-
Altitude	–60	-	5000	m	If the altitude is between 3000 m and 5000 m, the temperature decreases by 1°C for every 220 m increase in altitude.
Input characteristics					
Operating input voltage	–72	–48	–38	V	-
Maximum input current	-	-	55	A	V_{in} = –48 V; I_{out} = I_{onom}
No-load power	-	-	10	W	V_{in} = –48 V; V_{out} = –54 V, T_A =25°C, I_{out} = 0 A
Input capacitance	1950	-	-	µF	Aluminum electrolytic capacitor
Input reflected ripple current	-	-	10	% I_{innom}	Oscilloscope bandwidth: 20 MHz
Response to input transient	-	-	5	V	0.5 V/µs input transient; V_{in} = –72 V to –38 V; I_{out} ranges from 1 A to I_{onom}
Output characteristics					
Output voltage setpoint	–54.54	–54.00	–53.46	V	V_{in} = –48 V; I_{out} = 50%I_{onom}
Output current	0	-	44.5	A	-
Output power	0	-	2400	W	-
Line regulation	–2	-	2	% V_{out}	V_{in} = –72 V to –38 V; I_{out} = I_{onom}
Load regulation	–1	-	1	% V_{out}	V_{in} = –48 V
Output voltage regulation precision	–3	-	3	%	Full range of V_{in}, I_{out}, and T_A
Temperature coefficient	–0.02	-	0.02	%/°C	T_A = –40°C to +85°C
Output external capacitance	3760	-	22,000	µF	Aluminum electrolytic capacitor

Electrical Specifications

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Output characteristics					
Output voltage ripple and noise (peak to peak)	-	-	2500	mV	T_A = –40°C to –5°C; Bandwidth: 20 MHz
	-	-	800	mV	T_A ≥–5°C; Bandwidth: 20 MHz
Output voltage adjustment range	–58	-	–50	V	Adjusted by PMBus
Turn-on output voltage overshoot	–5	-	5	%	Full range of V_{in}, I_{out}, and T_A
Turn-on output voltage delay time	-	-	1000	ms	From V_{in} to 10% V_{out}
Output voltage rise time	-	-	200	ms	From 10% V_{out} to 90% V_{out} Load capacitor ≤ 18,000 µF
	-	-	300	ms	From 10% V_{out} to 90% V_{out} 18,000 µF < Load capacitor ≤ 22,000 µF
Switching frequency	-	300	-	kHz	-
Protection characteristics					
Input undervoltage protection Protection threshold Recovery threshold Hysteresis	 –34.5 –36 1.5	 - - -	 - - -	 V V V	 - - -
Output overcurrent protection	110	-	140	$\%I_{omax}$	Constant current mode, self-recovery
Output short circuit protection	-	-	-	-	Constant current mode, self-recovery
Output overvoltage protection Static setpoint	-	-	–63	V	≤ 100 ms. The protection mode can be set to self-recovery or latch-off mode. The default mode is latch-off.
Output overvoltage protection Dynamic setpoint	-	-	–68	V	≤ 100 µs.
Overtemperature protection Threshold Hysteresis	 105 5	 120 -	 130 -	 °C °C	Self-recovery The overtemperature protection hysteresis is obtained by measuring the temperature of the PCB near the temperature sensor.

Electrical Specifications

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Auxiliary power supply characteristics					
Aux_3V3 output voltage	3.0	3.3	3.6	V	Aux_3V3 to COM
Aux_3V3 output current	-	-	0.02	A	-
Aux_12V output voltage	10	12	14	V	Aux_12V to V_{in}(+)
Aux_12V output current	-	-	0.01	A	-
Parallel characteristics					
Maximum parallel output power	0	-	24,000	W	V_{in} = –72 V to –38 V
Current share imbalance	–5	-	5	%	50%–100% load; Modules less than 10 pcs.
	–10	-	10	%	50%–100% load; Mudules more than 10 pcs.
Current share adjustment	–1.5	-	1.5	V	V_{in} = –72 V to –38 V
PMBus detection precision					
Input power	–5	-	5	%	500–2400 W load; T_A ≥–5°C;
	–10	-	10	%	200–500 W load; T_A ≥–5°C;
	-	-	-	%	< 200 W load
Input voltage	–1	-	1	V	Full range of V_{in}
Output voltage	–1	-	1	V	-
Output current	–2	-	2	A	-
Internal temperature	–5	-	5	°C	-
Dynamic characteristics					
Overshoot amplitude Recovery time	–5 -	- -	5 2000	% µs	T_A ≥ –25ºC, Current change rate: 1 A/µs, T = 4 ms Load: 25%–50%–25%; 50%–100%–50%
Overshoot amplitude Recovery time	–10 -	- -	10 2000	% µs	T_A ≥ –25ºC, Current change rate: 0.1 A/µs, T = 4 ms Load: 10%–90%–10% With an additional 1000 µF output external capacitor

Electrical Specifications

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Efficiency					
50% to 100% load	98.0	98.5	-	%	T_A = 25°C, V_{in} = –53 V, V_{out} = –54 V
50% load	97.0	97.5	-	%	T_A = 40°C, V_{in} = –48 V, V_{out} = –54 V
100% load	96.0	96.5	-	%	T_A = 85°C, V_{in} = –38 V, V_{out} = –54 V
Insulation characteristics					
Input to baseplate insulation voltage	-	-	1500	V DC	Functional insulation (1-minute test); leakage current < 1 mA
Output to baseplate insulation voltage	-	-	1500	V DC	
Reliability characteristics					
Mean time between failures (MTBF)	-	2.5	-	Million hours	Telcordia, SR332 Method 1 Case 3; 80% load, normal input/rated output; airflow rate = 1.5 m/s (300 LFM); T_A = 40˚C

Specifications are subject to change without notice.

Characteristic Curves

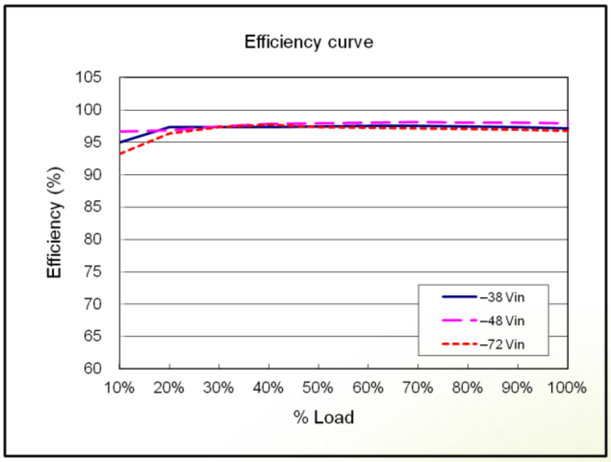


Figure 1: Efficiency (T_A = 25°C, V_{out} = –54 V)

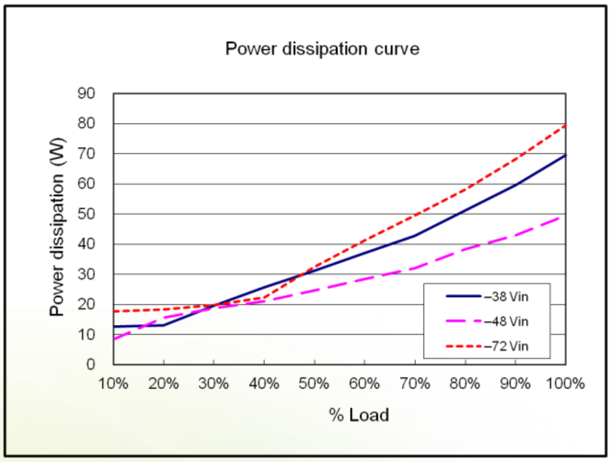


Figure 2: Power dissipation (T_A = 25°C, V_{out} = –54 V)

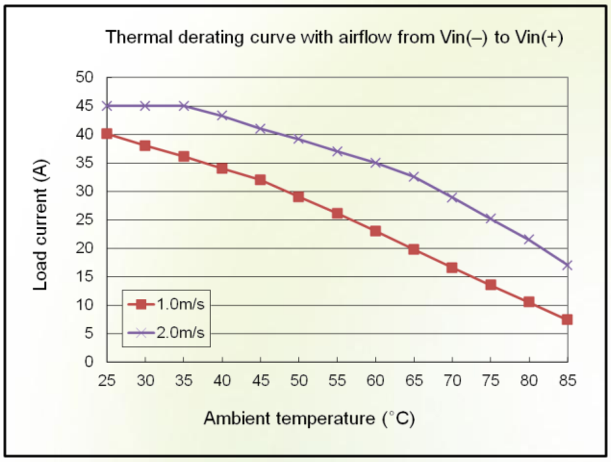


Figure 3: Thermal derating with airflow from Vin (–) to Vin (+) (V_{in} = –48 V, V_{out} = –54 V)

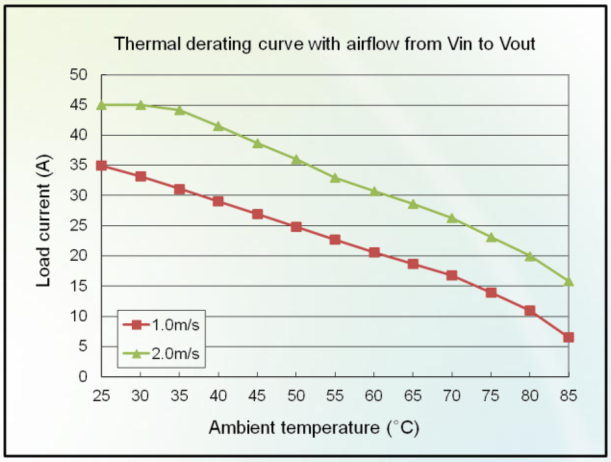


Figure 4: Thermal derating with airflow from Vin to Vout (V_{in} = –48 V, V_{out} = –54 V)

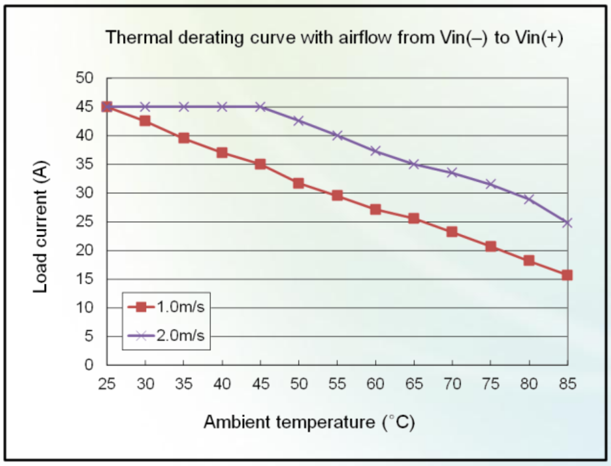


Figure 5: Thermal derating with airflow from Vin (–) to Vin (+) (V_{in} = –60 V, V_{out} = –54 V)

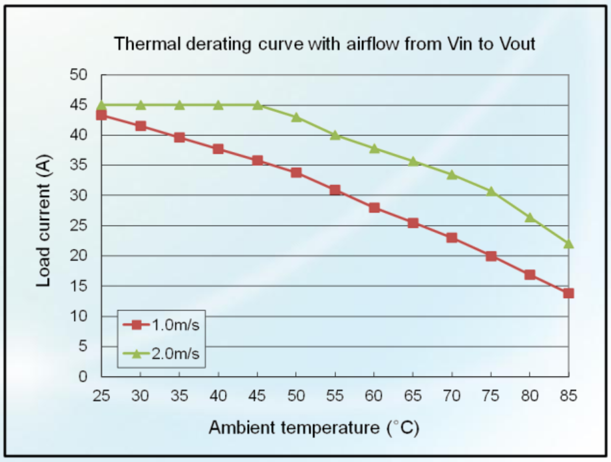


Figure 6: Thermal derating with airflow from Vin to Vout (V_{in} = –60 V, V_{out} = –54 V)

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. Point A is for testing the input reflected ripple current.
3. Points B and C are for testing the output voltage ripple.

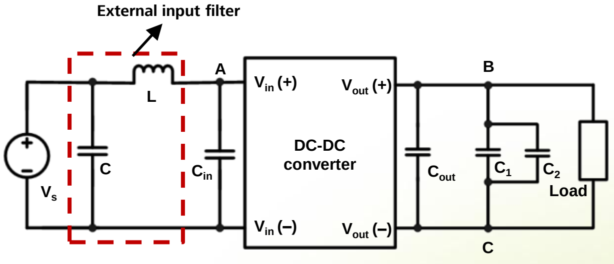


Figure 7: Test set-up diagram

C_{in}: The 1950 μF aluminum electrolytic capacitor is recommended.
C_{out}: The 3760 μF aluminum electrolytic capacitor is recommended.
C_1: The 0.1 μF ceramic capacitor is recommended.
C_2: The 10 μF aluminum electrolytic capacitor is recommended.

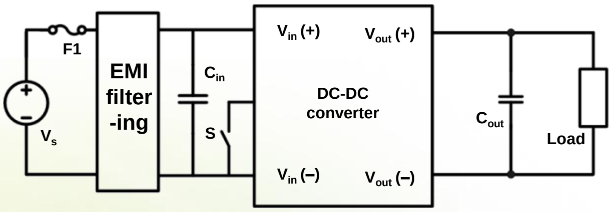


Figure 8: Typical circuit applications

F1: 2 x 40 A fuse (low-blow)
C_{in}: The 1950 μF aluminum electrolytic capacitor is recommended.
C_{out}: The 3760 μF aluminum electrolytic capacitor is recommended.

Typical Waveforms

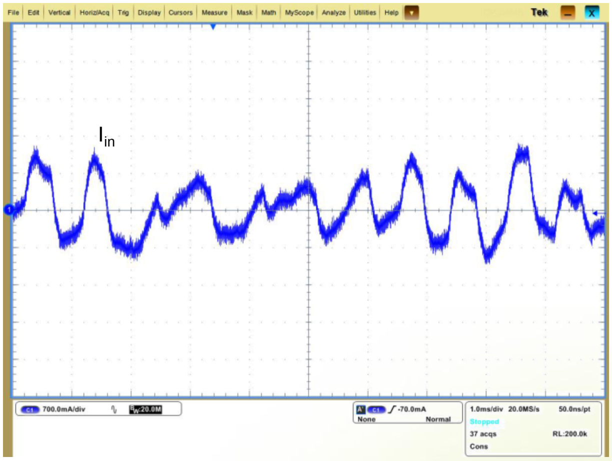


Figure 9: Input reflected ripple current
(for point A in the test set-up diagram, V_{in} = –48 V, V_{out} = –54 V, I_{out} = 44.5 A)

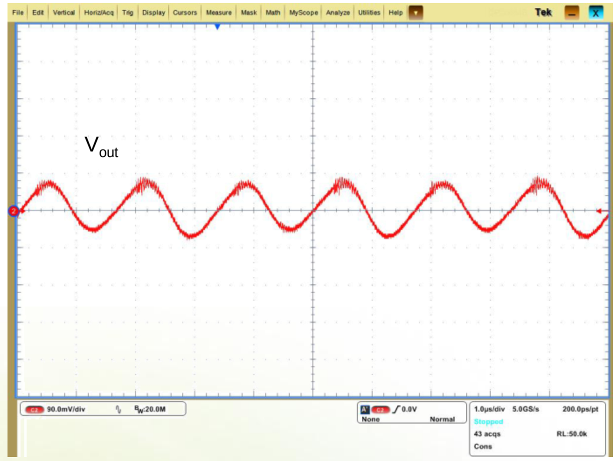


Figure 10: Output voltage ripple
(for points B and C in the test set-up diagram, V_{in} = –48 V, V_{out} = –54 V, I_{out} = 44.5 A)

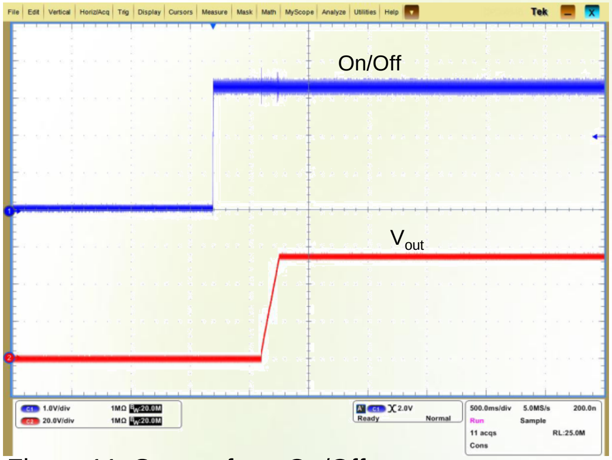


Figure 11: Startup from On/Off
(V_{in} = –48.0 V, V_{out} = –54.0 V, I_{out} = 44.5 A)

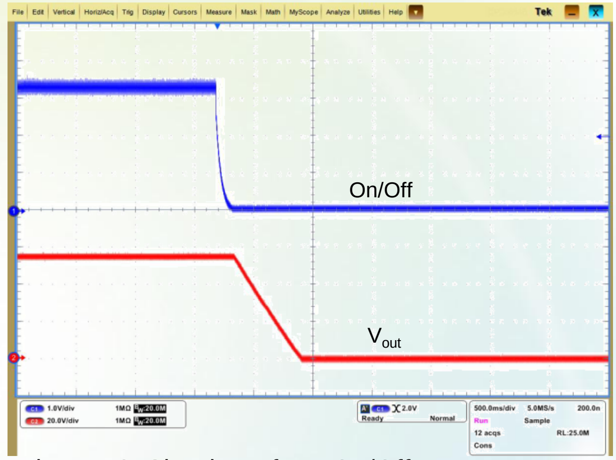


Figure 12: Shutdown from On/Off
(V_{in} = –48.0 V, V_{out} = –54.0 V, I_{out} = 44.5 A)

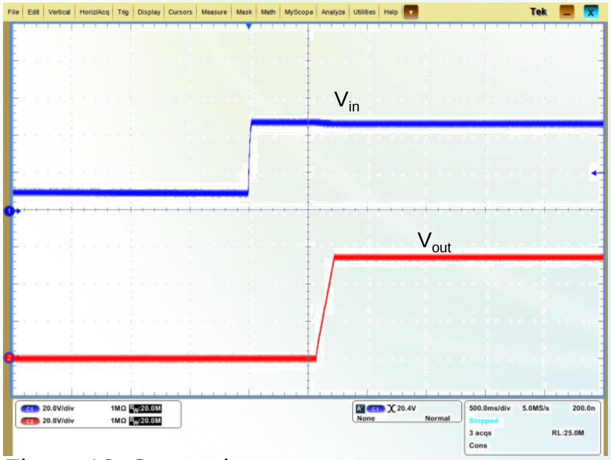


Figure 13: Startup by power-on
(V_{in} = –48.0 V, V_{out} = –54.0 V, I_{out} = 44.5 A)

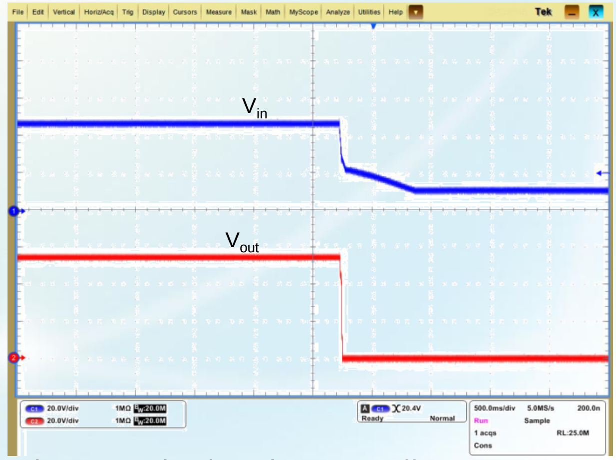


Figure 14: Shutdown by power-off
(V_{in} = –48.0 V, V_{out} = –54.0 V, I_{out} = 44.5 A)

Typical Waveforms

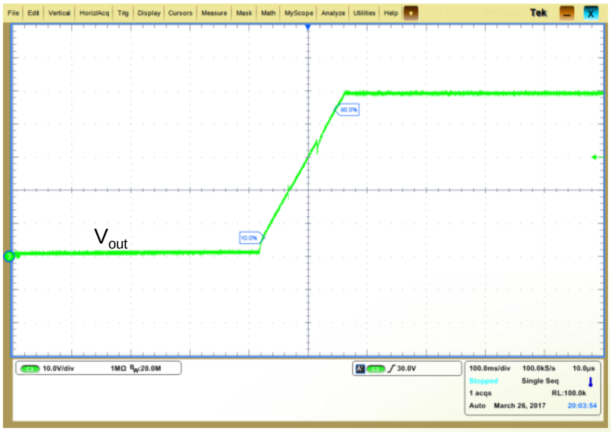


Figure 15: Startup by power-on
(V_{in} = –72.0 V, I_{out} = 44.5 A)

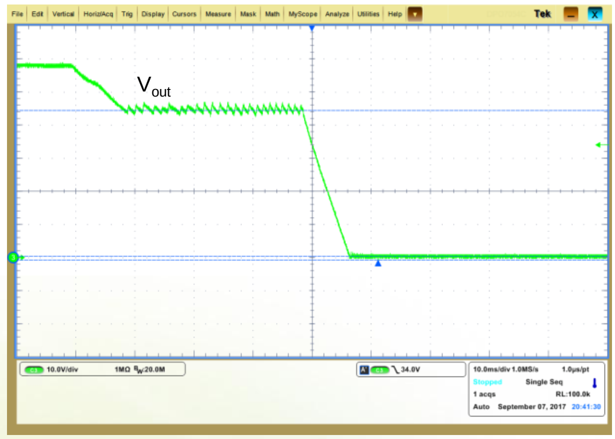


Figure 16: Shutdown from On/Off
(V_{in} = –72.0 V, I_{out} = 20.7 A)

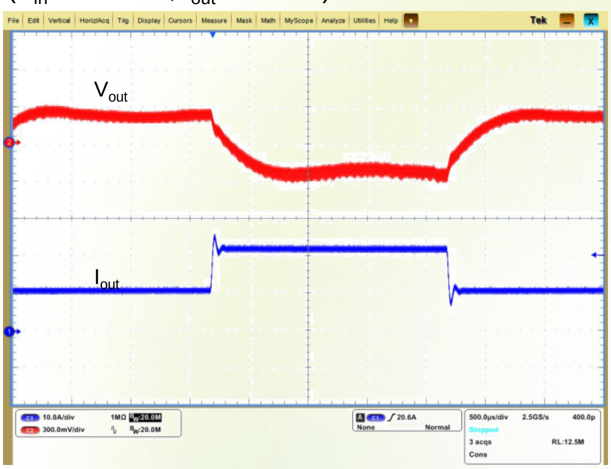


Figure 17: Output voltage dynamic response
(load: 25%–50%–25%, di/dt = 1 A/μs, T_A ≥ –25ºC)

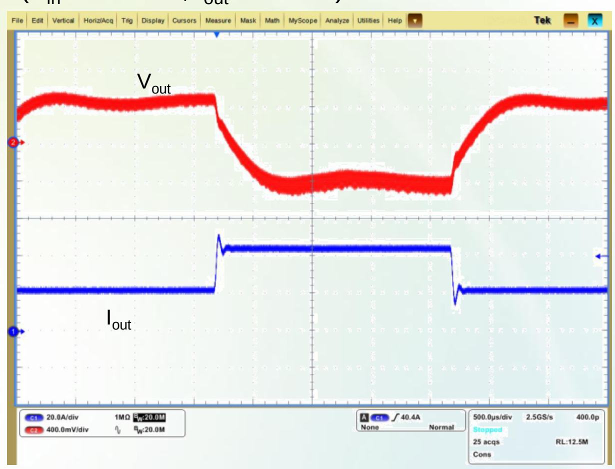


Figure 18: Output voltage dynamic response
(load: 50%–100%–50%, di/dt = 1 A/μs, T_A ≥ –25ºC)

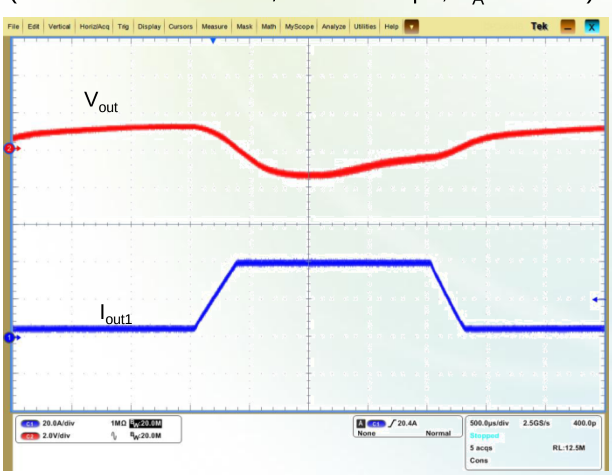


Figure 19: Output voltage dynamic response
(load: 10%–90%–10%, di/dt = 0.1 A/μs, T_A ≥ –25ºC)

Remote On/Off

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

On/Off Pin Level	Status
Low levele (–0.3 V, 0.8 V)	Off
High level (2.4 V, 3.6 V)	On

On/Off Signal	Min.	Typ.	Max.
On/Off current (high level)	0.1 mA	-	1 mA
Turn off pulse width	100 ms	-	-
Turn on delay time	-	-	1s

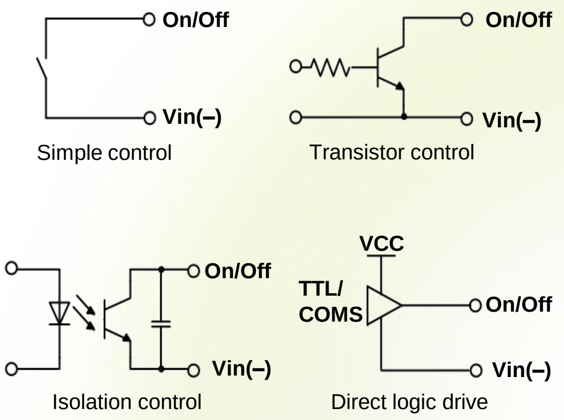


Figure 20: Various circuits for driving the On/Off pin

Load Regulation

The output voltage precision of the converter can be regulated using the LOADFB pin.

LOADFB Signal	Min.	Typ.	Max.
Input voltage	–0.3 V	-	3.6 V
Input current	-	-	0.004 A

Converter Addressing

Up to two converters can be addressed using the ADDR pin. When the addressing function is not used, leave the ADDR pin open.
To set the address, connect ADDR to COM or AUX_3V3 through a 4.7 kΩ resistor.

ADDR Pin Level	Address
Low level	0x58
High level	0x59

Parallel Operation

Twenty converters can be paralleled for current sharing using the CS_PWM pin. When the turn-on parallel output power exceeds 2400 W, there is no requirement on the output voltage waveform.

Logic Enable	Min.	Typ.	Max.
CS_PWM voltage	0 V	-	3.6 V
CS_LOAD voltage	0 V	-	3.6 V
CB voltage	0 V	-	3.6 V

Alarm Reporting

When the converter fails or input undervoltage protection, input overvoltage protection, output undervoltage protection, output overvoltage protection, or overtemperature protection occurs, the ALERT signal will indicate the alarm. The alarm type and overtemperature pre-warning will be reported through PMBus command and can be reset.

ALERT Signal	Min.	Typ.	Max.
Low level (no alarm)	–0.3 V	-	0.8 V
High level (alarm)	2.4 V		3.6 V
Alarm delay time after OTP	1 ms	-	-

PMBus Communication

Monitoring and Fault Detection

The converter communicates with the system over the PMBus. The GDC45S54BP-P provides the following monitoring and fault detection functions.

Monitors the following:

- Converter information
- Input power
- Input current
- Input voltage
- Output voltage
- Output current
- Output power
- Internal temperature

Detects the following:

- Input power failure
- Input undervoltage
- Input overvoltage
- Output overvoltage
- Output limiting current
- Output undervoltage
- Overtemperature

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 21 shows the interconnect diagram of SCL and SDA.

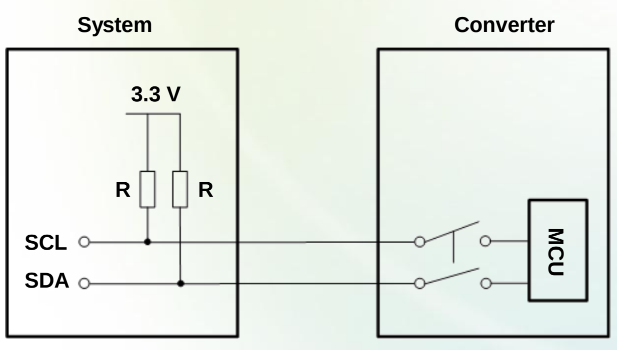


Figure 21: Interconnect diagram of SCL and SDA

SCL, SDA Signal	Min.	Typ.	Max.
Low level	–0.3 V	-	0.8 V
High level	2.4 V	-	3.6 V

The converter supports the 100 kHz (default) 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.

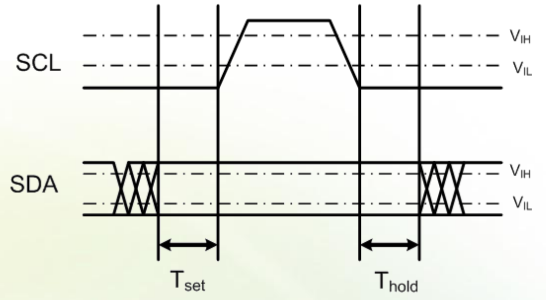


Figure 22: PMBus setup time and hold-up time

PMBus Commands

Hex Code	Command Name	Data Type	Data Bytes	Data Format
Control command				
01h	OPERATION	ReadByte /Write	1	Unsigned
MFR commands				
E4h	PMBUS_CMD_SW_VERSION	Read Word	2	Unsigned
E9h	PMBUS_CMD_RESET_CTRL	Write Byte	1	Unsigned
21h	PMBUS_CMD_VOUT_COMMAND	Read/Write Word	2	Unsigned
41h	PMBUS_CMD_VOUT_OVP_RESPONSE	Read/Write Byte	1	Unsigned
EDh	PMBUS_CMD_VOUT_SET	Read/Write Word	2	Unsigned
EEh	PMBUS_CMD_IOUT_SET	Read/Write Word	2	Linear 11
FAh	PMBUS_CMD_UPDATE_TIME	Read/Write Block	4	Unsigned
FCh	PMBUS_CMD_LOAD_START	Read/Write Word	2	Unsigned
FDh	PMBUS_CMD_LOAD_DATA	Write Word	2	Block

PMBus Communication

PMBus Commands

Hex Code	Command Name	Data Type	Data Bytes	Data Format
Monitor command				
79h	STATUS_WORD	Read Word	2	Unsigned
88h	READ_VIN	Read Word	2	Linear 11
89h	READ_IIN	Read Word	2	Linear 11
8Bh	READ_VOUT	Read Word	2	Q9
8Ch	READ_IOUT	Read Word	2	Linear 11
8Dh	PMBUS_CMD_TARGET_TEMP_1	Read Word	2	Linear 11
8Eh	PMBUS_CMD_TARGET_TEMP_2	Read Word	2	Linear 11
8Fh	PMBUS_CMD_TARGET_TEMP_3	Read Word	2	Linear 11
96h	READ_POUT	Read Word	2	Linear 11
97h	READ_PIN	Read Word	2	Linear 11
99h	PMBUS_CMD_READ_MFR_ID	Read Block	6	Unsigned
9Dh	PMBUS_CMD_MFR_DATA	Read Block	10	Unsigned
9Eh	PMBUS_CMD_MFR_SN	Read Block	16	Unsigned

Data Format

●Linear 11 data format

The linear data format is a two byte value with an 11-bit, binary signed mantissa (two's complement) and a 5-bit, binary signed exponent (two's complement), as shown in Figure 23.

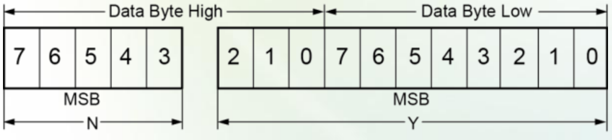


Figure 23: Linear 11 data format

The relationship between the N, Y, and the 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).

●VOUT data format

Commands related to output voltage is the READ_VOUT. The data for these commands is a 16-bit unsigned integer, as shown in Figure 24.

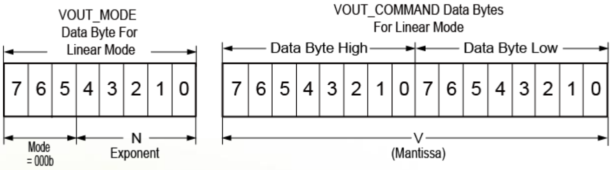


Figure 24: VOUT data format

The output voltage is calculated as follows:

$$\text{Voltage} = V \times 2^N$$

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

Command Descriptions

OPERATION (01h): Powers on or off the converter or clears the latch-off state.

Operation	Data
ON	0x80
OFF	0x00

PMBUS_CMD_VOUT_COMMAND (21h): Changes the output voltage of the converter. The default value is –54 V. Voltage adjustment range: –58 V to –50 V.

PMBUS_CMD_RESET_CTRL (E9h): Clears the latch-off caused by output overvoltage or current limiting. 0x55: Clears the latch-off state.

PMBUS_CMD_VOUT_OVP_RESPONSE (41h): Sets the output overvoltage protection mode. 0x00 (default): latch-off mode; 0x55: hiccup mode

STATUS_WORD (79h): Reads the converter alarm status.

PMBus Communication

Data	Status
Bit 0	Input power off
Bit 1	Input undervoltage
Bit 2	Input overvoltage
Bit 3	Output overvoltage
Bit 4	Output current limiting
Bit 5	Output undervoltage
Bit 6	Overtemperature
Bit 7	Reserved
Bit 8	EEPROM fault
Bit 9	Remote alarm
Bit 10	Reserved
Bit 11	Latch-off when aged
Bit 12	Input overvoltage fault
Bit 13 – Bite 15	Reserved

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 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 setpoint, the converter enters constant current mode for 10s at least. When the fault condition is removed, the converter will automatically restart.

Output Overvoltage Protection

Two modes are available for output overvoltage protection: latch-off (default) and self-recovery. The two modes can be switched between each other using a PMBus command. When the output voltage exceeds the overvoltage protection threshold, the output will shut down. In latch-off mode, if the fault condition is removed, the converter can turn on again after restarting the converter input. In self-recovery 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.

Recommended Fuse

The converter has no internal fuse. To meet safety requirements, a 2 x 40 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.

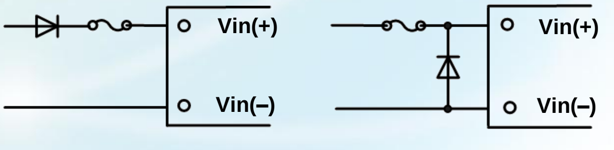


Figure 25: Recommended reverse polarity protection circuits

Standard Heatsink Mechanical Diagram

The thermal derating curves are tested when a heat sink is installed on the converter and the forced air cooling mode is used.

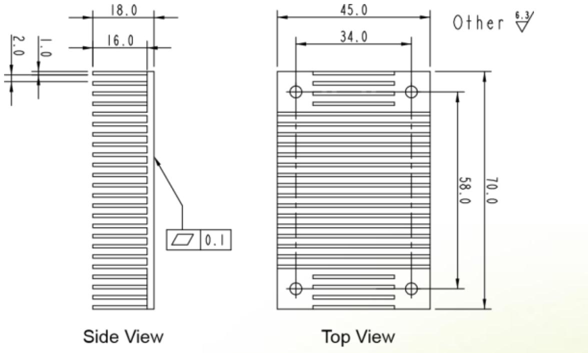


Figure 26: Standard heat sink for airflow from V_{in} (–) to V_{in} (+)

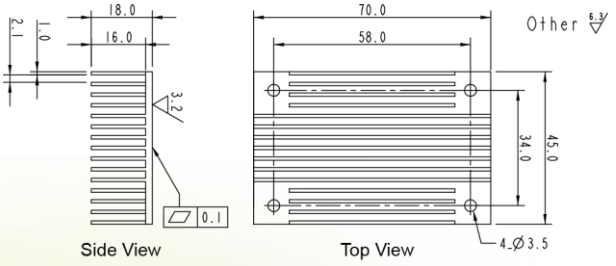


Figure 27: Standard heat sink for airflow from V_{in} to V_{out}

Qualification Testing

Parameter	Units	Condition
Highly accelerated life test	3	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
Thermal shock	32	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	32	Maximum input voltage; 85°C; 85% RH; 1200 operating hours under lowest load power
High temperature operation bias	32	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	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	32	Ambient temperature between +30°C and +60°C; 50% to 80% load, T = 6 months

Thermal Consideration

Thermal Test Point

Decide proper airflow to be provided by measuring the temperature at the middle of the baseplate shown in Figure 28 to protect the converter against overtemperature. The overtemperature protection threshold is obtained based on this thermal test point.

Figure 28: 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 1 specified in the J-STD-020/033. 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.

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 converter pins can be soldered at 260°C for less than 7 seconds.
2. 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 suitable solvents.

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