GAE10S05
DC-DC Converter Technical Manual V1.0

Date: 2011-11-16

HUAWEI

Eighth-Brick DC-DC Converter	**36–75 V Input**	**5 V Output**	**10 A Current**	**Negative Logic**

Description

The GAE10S05 is an isolated DC-DC converter that uses an industry-standard eighth-brick structure, and features high efficiency and power density. It has the dimensions of 9.7 mm x 22.86 mm x 57.9 mm (0.38 in. x 0.90 in. x 2.28 in.) and provides the rated output voltage of 5 V and the maximum output current of 10 A.

GAE10S05

Operational Features

- Input voltage: 36–75 V
- Output current: 0–10 A
- Low output ripple and noise
- Efficiency: 92.5% (5 V, 10 A)

Mechanical Features

- Industry standard eighth-brick (H x W x D, 9.7 mm x 22.86 mm x 57.9 mm (0.38 in. x 0.90 in. x 2.28 in.)
- Weight: about 50 g

Control Features

- Remote on/off
- Remote sense
- Output voltage trim

Protection Features

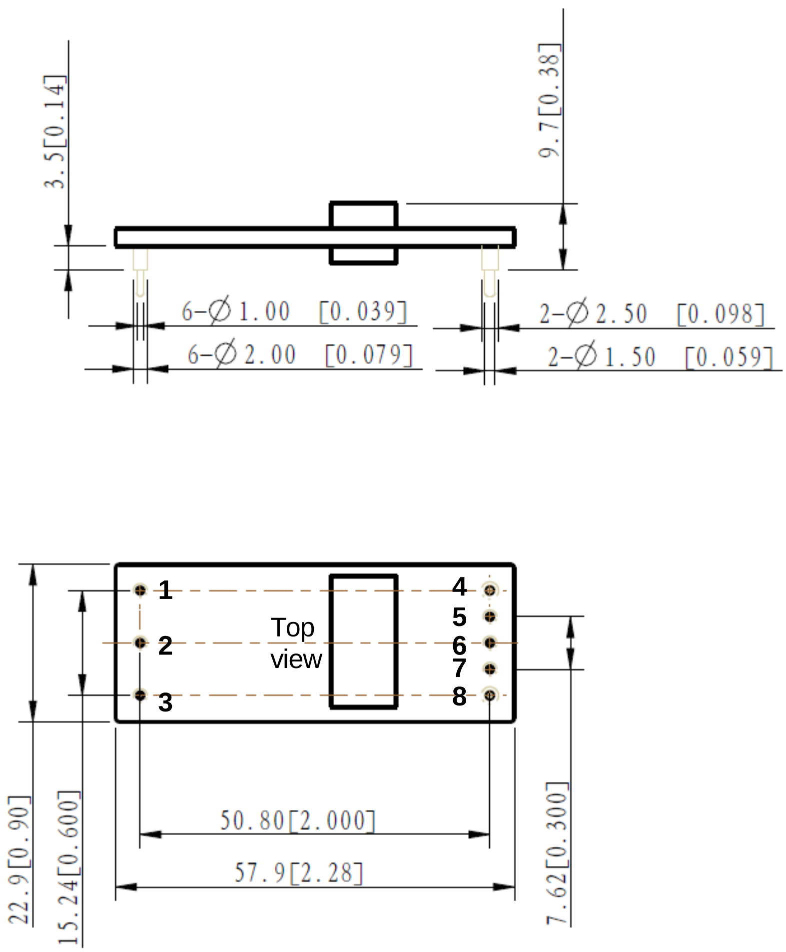
- Input undervoltage protection
- Output overcurrent protection (hiccup mode)
- Output short circuit protection (hiccup mode)
- Output overvoltage protection (hiccup mode)
- Overtemperature protection (self-recovery)

Safety Features

- UL60950-1 and IEC/EN60950
- Underwriters Laboratory (UL) certification
- Class A requirements in FCC and EN55022 (after connecting to an external filtering circuit)
- UL94V-0
- Restriction of the use of certain hazardous substance (RoHS) 6

Mechanical Diagram

Unit of measurement: mm (in.)



Pin description

Pin No.	Function
1	V_{in} (+)
2	CNT
3	V_{in} (–)
4	V_{out} (+)
5	Sense (+)
6	Trim
7	Sense (–)
8	V_{out}(–)

Dimensions tolerance

.x	± 0.2 mm (0.008 in.)
.xx	±0.13 mm (0.006 in.)

Designation Explanation

G	A	E	10	S	05
1	2	3	4	5	6

1 — Isolated
2 — Analog
3 — Eighth-brick
4 — Output current
5 — Single output
6 — Output voltage: 5 V

Electrical Specifications

Conditions: T_A = 25°C (77°F), Airflow = 1.0 m/s (200 LFM), Vin = 48 V, Vout = 5 V， unless otherwise specified.

Parameter	Min.	Typ.	Max.	Units	Remarks
Absolute maximum ratings					
Input voltage Continuous Transient (100 ms)	 - -	 - -	 80 100	 V V	 - -
Operating ambient temperature	–40	-	85	ºC	See the thermal derating curve.
Storage temperature	–55	-	125	ºC	-
Operating humidity	10	-	95	% RH	Non-condensing
Input characteristics					
Operating input voltage	36	48	75	V	-
Maximum input current	-	-	2.5	A	-
No-load loss	-	1.68	-	W	V_{in} = 48 V
Input capacitance	100	-	-	µF	Electrolytic capacitor
Inrush transient	-	-	1	A²s	-
Input reflected ripple current	-	14	20	mA	Oscilloscope bandwidth: 5–20 MHz
Output characteristics					
Output voltage setpoint	4.95	5.0	5.05	V	V_{in} = 48 V, Iout=10A
Output power	-	-	50	W	-
Output line regulation	-	0.2	1.0	%Vo	-
Output load regulation	-	0.5	1.0	%Vo	-
Temperature coefficient	-	-	0.02	%Vo/°C	T_A = –40°C to +85°C (–40°F to +185°F)
Regulated voltage precision	-	2.0	3.0	%Vo	The whole range of V_{in} , I_{out} and T_A
External capacitance	220	470	5000	µF	-
Output current	0	-	10	A	-
Output ripple and noise	-	50	100	mV	Oscilloscope bandwidth: 20 MHz
Output voltage adjustment range(trim)	80	-	110	%Vo	-
Out voltage overshoot	-	-	5	%Vo	The whole range of V_{in} , I_{out} and T_A
Output voltage rise time	-	10	20	ms	The whole range of V_{in} , I_{out} and T_A
Switching frequency	-	280	-	kHz	-

Electrical Specifications

Conditions: T_A = 25°C (77°F), Airflow = 1.0 m/s (200 LFM), Vin = 48 V, Vout = 5 V， unless otherwise specified.

Parameter	Min.	Typ.	Max.	Units	Remarks
Protection Features					
Input undervoltage protection Startup threshold Shutdown threshold	 31 30	 33.6 31.6	 36 35	 V V	 - -
Output overcurrent protection	11	-	14	A	Hiccup mode
Output short circuit protection	-	-	-	-	Hiccup mode
Output overvoltage protection	6.0	-	7.5	V	Hiccup mode
Overtemperature protection Threshold Hysteresis	 105 5	 115 -	 125 -	 °C °C	Self-recovery The values are obtained by measuring the PCB near the thermal resistor of the GAE10S05.
Dynamic Characteristics					
Overshoot amplitude Recovery time	- -	- -	250 200	mV µs	Current change rate: 0.1 A/µs load : 25%–50%–25%; 50%–75%–50%
Overshoot amplitude Recovery time	- -	- -	130 130	mV µs	Current change rate: 1 A/µs load : 25%–50%–25%; 50%–75%–50% Ta =25° C, additional 220µF load capacitor
Efficiency					
100% load	-	92.5	-	%	V_{in} = 48 V; I_{out} = 10 A; T_A=25°C (77°F)
50% load	-	91.2	-	%	V_{in} = 48 V; I_{out} = 5 A; T_A = 25°C (77°F)
20% load	-	85.3	-	%	V_{in} = 48 V; I_{out} = 2 A; T_A = 25°C (77°F)
Isolation characteristics					
Input-to-output Isolation voltage	-	1500	-	V DC	Basic Isolation
Other features					
Remote on/off voltage Low level High level	 -0.7 3.5	 - -	 1.2 12	 V V	 - -
On/Off current Low level High level	 - -	 - -	 1.0 -	 mA µA	 - -
Reliability characteristics					
Mean time between failures (MTBF)	-	1.5	-	Million hours	Airflow = 1.5 m/s (300 LFM); T_A = 40°C (104° F); 80% load; Telcordia SR332 Method 1 case 3

Qualification Testing

Parameter	Units	Condition
High accelerated life test (HALT)	4	Lowest operating temperature: –60°C (–76°F); highest operating temperature: 110°C (230°F); vibration limit: 40 G
Thermal shock	32	500 temperature cycles between –40°C (–40°F) and +125°C (+257°F) with the temperature change rate of 20°C (68°F) per minute Lasting for 30 minutes both at –40°C (–40°F) and +125°C (+257° F)
Temperature humidity bias	16	85°C (185°F); 85% RH; 1000 operating hours under lowest load
High Temperature Operation Life (HTOL)	16	Rated input voltage; Airflow :2.0 m/s (400 LFM); Ambient temperature: 50°C(122°F) ;1000 operating hours under 50%–80% load

Characteristic Curves

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

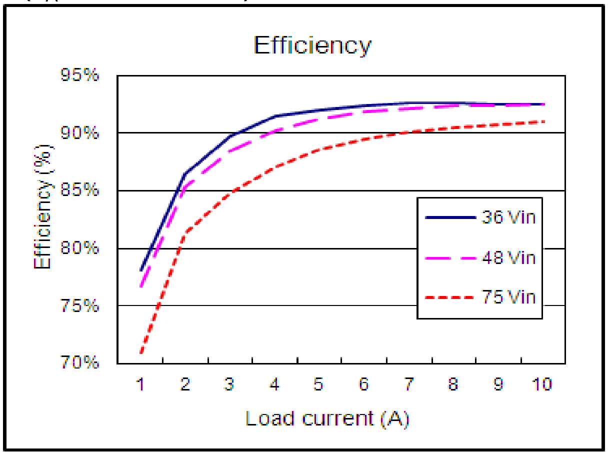


Figure 2: Power dissipation
(T_A = 25°C or 77°F)

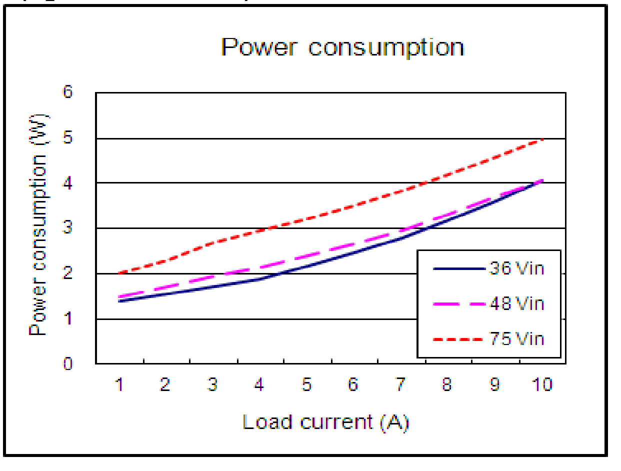


Figure 3: Thermal derating air is flowing from Vin to Vout (V_{in} = 48 V; V_{out} = 5 V)

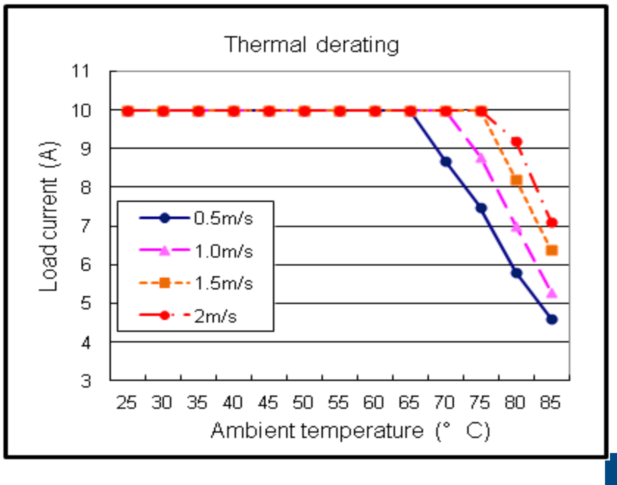


Figure 4: Thermal derating air is flowing from Vin(-) to Vin(+)(V_{in} = 48 V; V_{out} = 5 V)

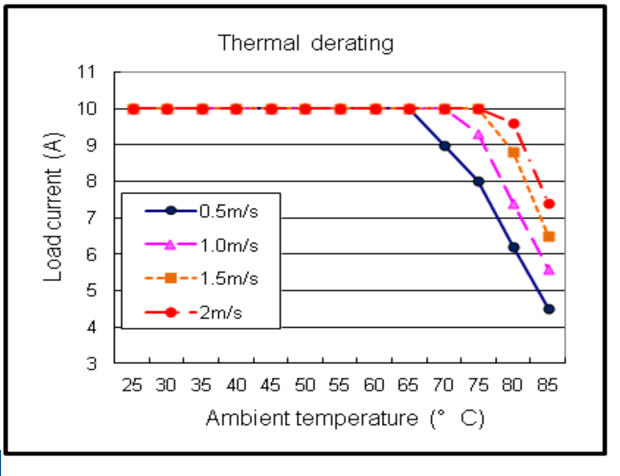


Figure 5: Thermal plot air is flowing from Vin to Vout(T_A = 25°C (77°F); Airflow = 1.0 m/s (200 FLM); Vin = 48 V; Vout = 5 V; Iout = 10 A)

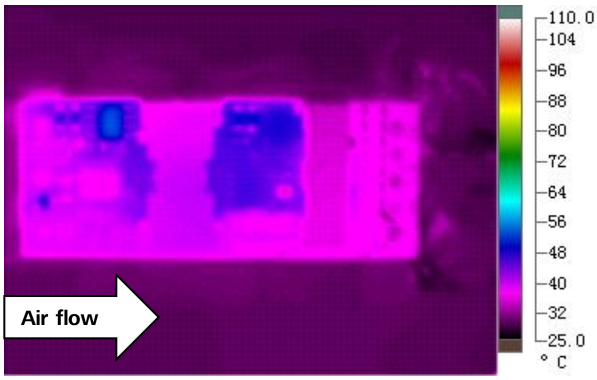
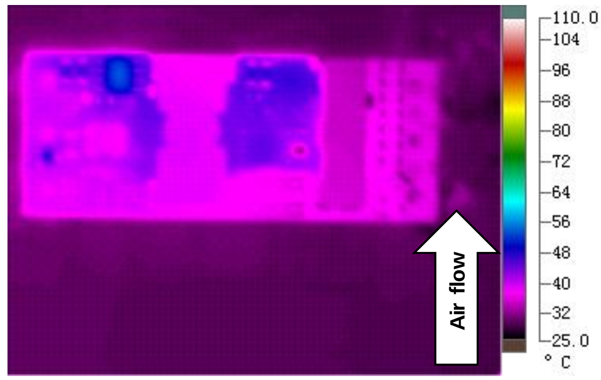


Figure 6: Thermal plot air is flowing from Vin(-) to Vin(+)(T_A = 25°C (77°F); Airflow = 1.0 m/s (200 FLM); Vin = 48 V; Vout =5 V; Iout = 10 A)



Typical Waveforms

Conditions: T_A = 25°C (77°F), Vin = 48 V.

Figure 7: Startup from CNT

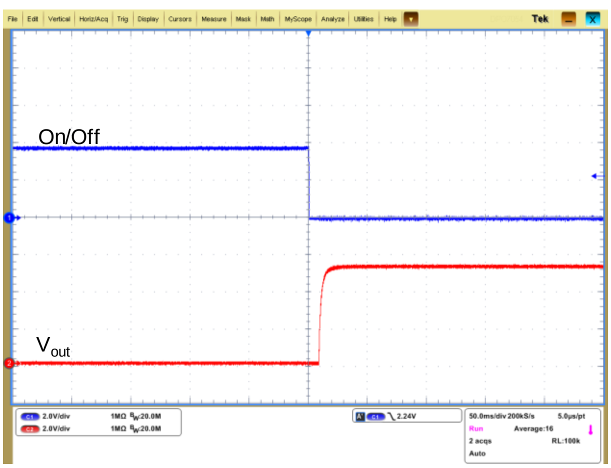


Figure 8: Shutdown from CNT

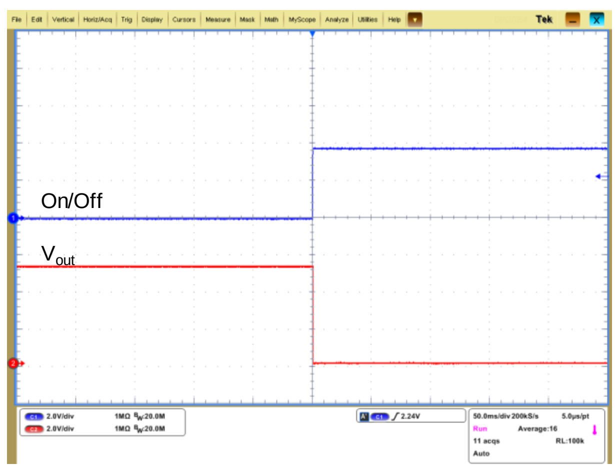


Figure 9: Startup from power on

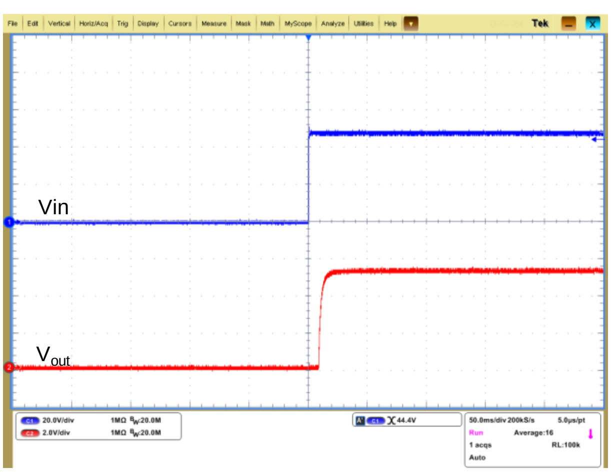


Figure 10: Shutdown from power on

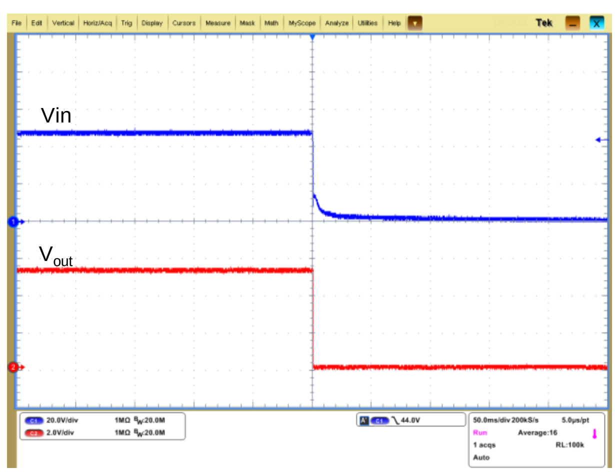


Figure 11: Output voltage response
(Load : 25%–50%–25%, dI/dt=0.1 A/µs)

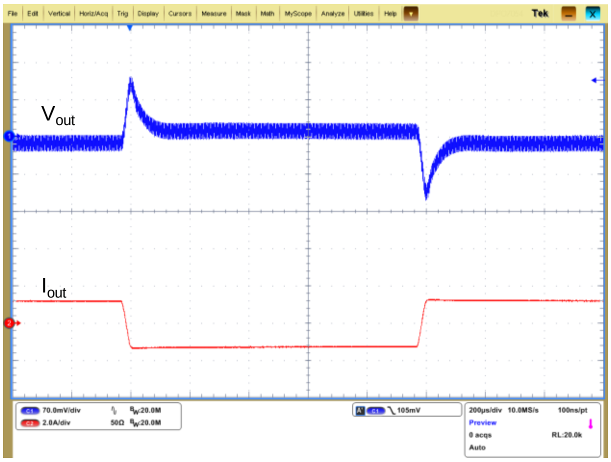


Figure 12: Output voltage response
(Load 50%–75%–50%, dI/dt=0.1 A/µs)

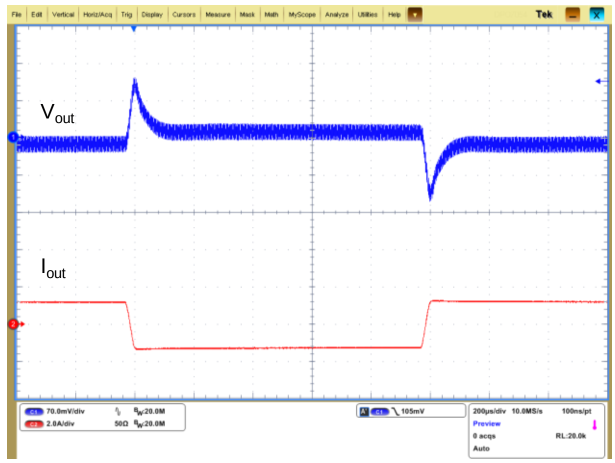
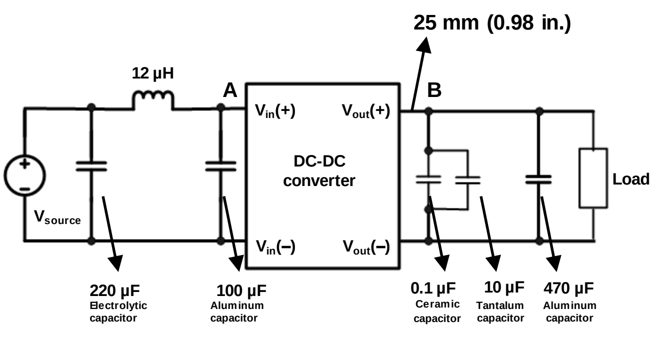


Figure 13: Test set-up diagram



NOTE

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

Conditions: T_A = 25°C (77°F) ,Vin = 48 V, Vout = 5 V, Iout = 10 A.

Figure 14: Input reflected ripple current
(for point A in the test set-up diagram)

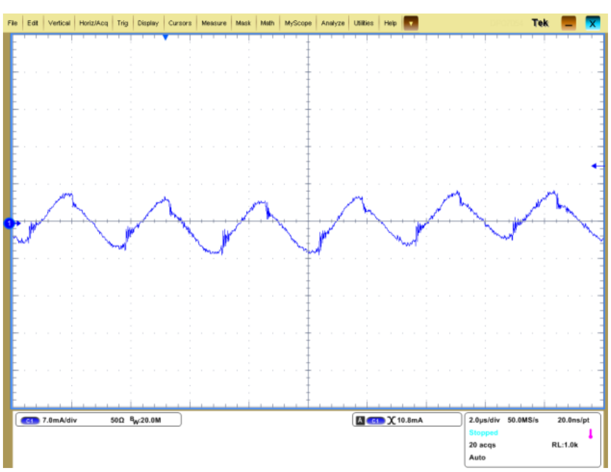
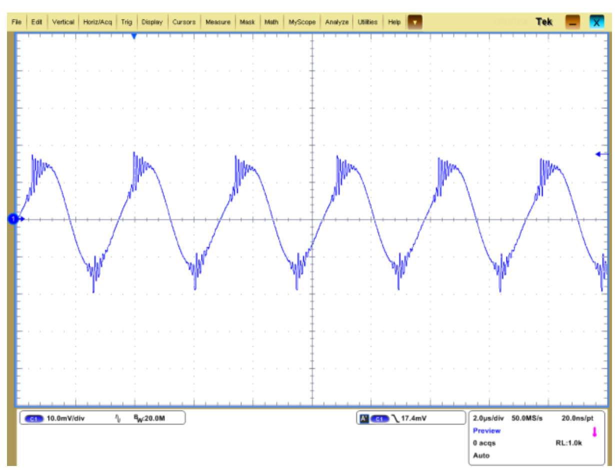


Figure 15: Output voltage ripple
(for point B in the test set-up diagram)

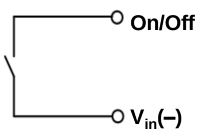


Feature Description

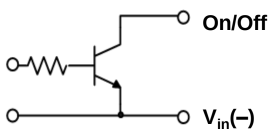
Remote On/Off

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

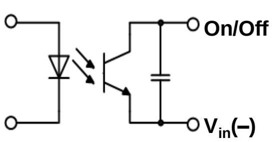
The following are some circuits for driving the on/off pin.



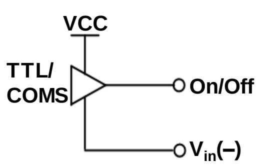
Simple control



Transistor control



Isolation control



Direct logic drive

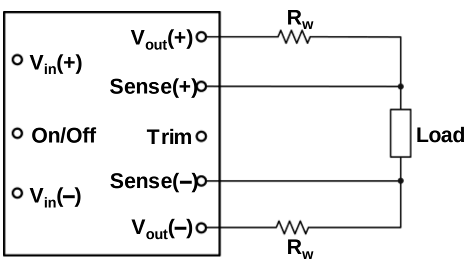
Remote Sense

This function is used to compensate for voltage drops on circuits.

The Sense(+), Sense(–), $V_{out}(+)$, and $V_{out}(–)$ terminals should meet the following requirements:
$[V_{out}(+) – V_{out}(–)] – [Sense(+) – Sense(–)] \leq 10\% \times V_{nom}$ (V_{nom} is the rated output voltage.)

If the remote sense function is disabled, the Sense(+) terminal connects to the $V_{out}(+)$ terminal and the Sense(–) terminal connects to the $V_{out}(–)$ terminal at the output end.

Figure 16: Configuration diagram for remote sense



R_w indicates the line impedance between the output end and the load.

Output Voltage Trim

The output voltage can be adjusted within the range of 80% V_{nom} to 110% V_{nom} using a trim pin.

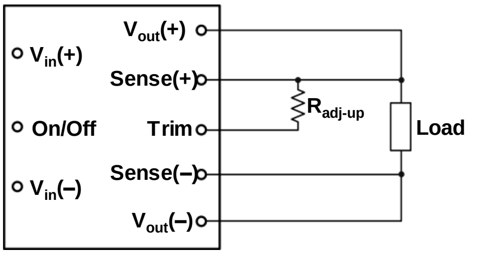
NOTE

If the trim pin is not used, it should be left open.

Trim Up

The output voltage can be increased by installing an external resistor between the trim pin and the Sense(+) terminal.

Figure 15: Configuration diagram for raising the output voltage



The following formula reflects the relationship between R_{adj-up} and V_{out}:

$$R_{adj-up} = \frac{5.1 \times V_{nom} \times (100 + \Delta)}{1.225 \times \Delta} - \frac{510}{\Delta} - 10.2 (kohm)$$

Where, $\Delta = \frac{V_{trim-up} - V_{nom}}{V_{nom}} \times 100$

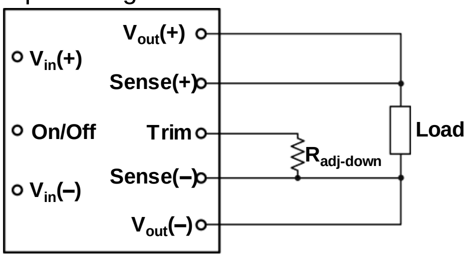
NOTE

Although the output voltage can be increased by both the remote sense and trim functions, the maximum increase in the output voltage is the larger value, rather than the sum of both values.
The GAE10S05 loading capability decreases as the voltage increases. Therefore, you need to ensure that the actual output power does not exceed the maximum output power when raising the voltage.

Trim Down

The output voltage can be decreased by installing an external resistor between the trim pin and the Sense(–) terminal.

Figure 16: Configuration diagram for lowering the output voltage



The following formula reflects the relationship between $R_{adj\text{-}down}$ and V_{out}:

$$R_{adj-down} = \frac{510}{\Delta} - 10.2(kohm)$$

Where, $$\Delta = \frac{V_{nom} - V_{trim-down}}{V_{nom}} \times 100$$

Input Undervoltage Protection

The GAE10S05 is shut down after the input voltage drops below the undervoltage protection threshold for shutdown. The GAE10S05 starts to work again after the input voltage reaches the input undervoltage protection threshold for startup.

Output Overcurrent Protection

When the output current exceeds the overcurrent protection threshold, the GAE10S05 works in hiccup mode until overcurrent disappears. After the output current drops to the specified range, the GAE10S05 starts to work in normal mode.

Output Overvoltage Protection

When the output voltage exceeds the overvoltage protection threshold, the GAE10S05 works in hiccup mode.

Overtemperature Protection

The overtemperature function protects the GAE10S05 from being damaged at high temperatures. When the GAE10S05 temperature exceeds the overtemperature protection threshold, the output is disabled. After the GAE10S05 temperature drops below the overtemperature threshold, the GAE10S05 starts to work again.

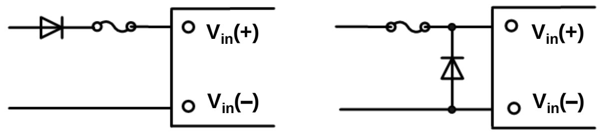
MTBF

The MTBF is calculated according to the Telcordia, SR332 Method 1 Case3.
If the GAE10S05 is used at 40°C (104°F), the airflow over it can be increased to retain the MTBF.

Recommended Reverse Polarity Protection Circuit

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

Figure 17: Recommended reverse polarity protection circuits



Recommended Fuse

The GAE10S05 has no internal fuse, but connects to an external fuse in actual use. To meet safety and regulatory requirements, a 4 A fuse is recommended.

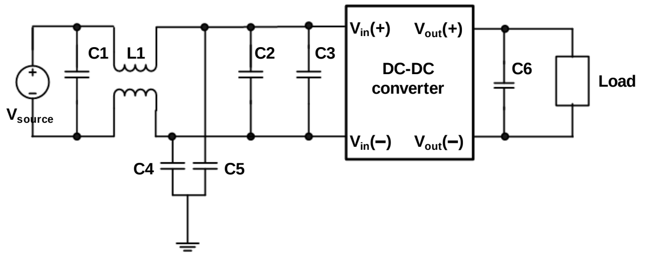
NOTE

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

EMC

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

Figure 18: EMC test set-up diagram



C1: Surface mount device (SMD) ceramic capacitor (100 V/1000 nF/X7R/1210)

C2: SMD ceramic capacitor (100 V/100 nF/±10%/X7R/1206)

L1: Common-mode inductor (single phase, 1320 µH/±25%/4 A/R5K/ 21 mm x 21 mm x 12.5 mm [0.83 in. x 0.83 in. x 0.49 in.]). The chip component with the same specifications can also be used.

C4: Plug-in film safety regulation capacitor (0.022 µF/250 V), meeting the 1 kV pressure resistance requirement.

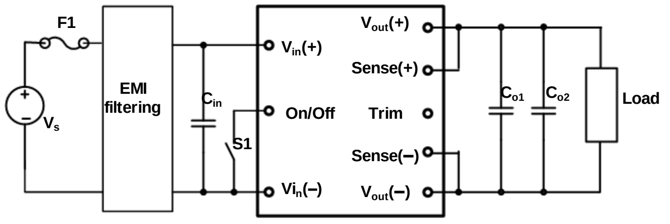
C5: High-pressure resistant chip ceramic capacitor (22 nF/1000 V/X7R/1210). Chip ceramic capacitors are preferred.

C3: Aluminum capacitor (100 µF)

C6: Aluminum capacitor (470 µF)

Typical Application

Figure 19: Typical circuit applications



F1: 4 A fuse (fast blowing)
C_{in}: The high-frequency, low equivalent series resistance (ESR) electrolytic capacitor (100 µF /100 V) is recommended.
C_{o1}: The 1 µF ceramic capacitor is recommended.
C_{o2}: The 470 µF tantalum capacitor is recommended.

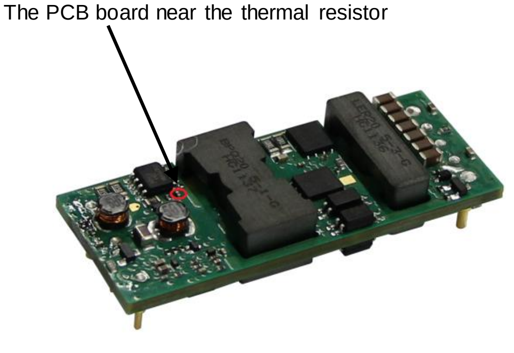
NOTE

GAE10S05s cannot be connected in parallel.

Thermal Consideration

Sufficient airflow should be provided to help ensure reliable operating of the GAE10S05. Therefore, Proper airflow can be verified by measuring the The PCB board near the thermal resistor.

Figure 20: Thermal test point



NOTE

The temperature at the thermal test point on the GAE10S05 cannot exceed 105°C (221°F). Otherwise, the GAE10S05 will be protected against overtemperature and will not operate properly.

Power Dissipation

The GAE10S05 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):

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

Mechanical Considerations

Installation

Although the GAE10S05 can be mounted in any direction, free airflow must be taken. Normally power components are always installed at the end of the airflow path or have separate airflow paths. The installation mode helps keep other system equipment cooler and increase component service life.

Soldering

The GAE10S05 is compatible with standard wave soldering techniques. During wave soldering, the setting parameters should base on the speciality of using flux, such as the preheating temperature and time, the soldering temperature and time and so on. To improve the soldering heighten, it is allowed to improve the preheating and soldering temperature, prolong the preheating and soldering time as the larger thermal capacity of the module. However, it is not allowed to excess the high temperature limitation of the components that belong to the module.

When soldering the GAE10S05, ensure that the soldering iron is at 425°C (797°F) and contacts pins for a maximum of 3 seconds, because long-time soldering at high temperatures may cause the GAE10S05 interior to be damaged.

The GAE10S05 can be rinsed using the isopropyl alcohol (IPA) solvent or other proper solvents.

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