

SA50-28 Single Series

Radiation-Hardened Isolated DC-to-DC Converter

Introduction

The SA50-28 is an Isolated DC-to-DC converter capable of delivering up to 50W of output power in a small size design. The SA family provides a radiation hardened option with top class TID and SEE performance for space and military applications. With forward converter topology and a patented magnetic feedback, the SA50-28 is optimized for applications where isolated DC voltage conversion is required. The discrete surface mount design facilitates customization with reasonable lead time and modest NRE cost.

To achieve MIL-STD-461 EMI compliance, an external filter is required. Off the shelf filters such as Microchip's SF200-28-28S are available.

As the only non-hybrid space grade DC-DC power converter module in the market, the SA50-28 series excels in its robustness in the applications with 8.22x10⁶ hours of MTBF.

The SA50-28 is available in 3.055" x 2.055" x 0.5" package.

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1. Benefits and Features

- Up to 56W output Power (Parallel up to 5 for higher power)
- · 20VDC to 40VDC input range
- · 5 output configurations available

Output	Base Part number
3.3V	SA50-28-3R3S
5V	SA50-28-5S
12V	SA50-28-12S
15V	SA50-28-15S
28V	SA50-28-28S

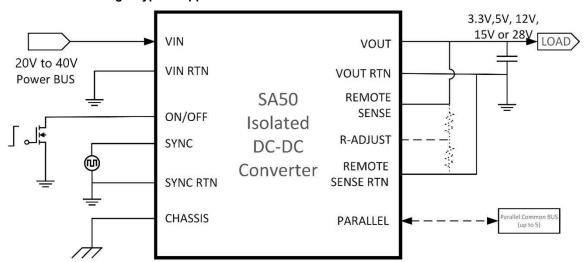
- · Up to 82% efficiency @ full load
- <1% output ripple</p>
- Forward topology
- · Patented magnetic feedback
- Adjustable output with remote adjust
- Inhibit pin for electrical ON/OFF
- · Capable of paralleling up to 5 identical units.
- · Isolated synchronization input
- Low mass 120g
- Flight proven technology with >8 x 10⁶ hours of MTBF
- · This product is classified as EAR99
- Customization of input/output voltages available upon request.

Radiation Performance

- TID>100krad(Si) and 30krad(Si) ELDRS (<10mrad/s) per MIL-STD-883 Method 1019
- SEE (SEGR, SEB, SET, SEL) immunity 82 MeV·cm²/mg

2. Typical Application Circuit

Figure 2-1. SA50-28 Single Typical Application Circuit



3. Absolute Maximum Ratings

Rating	Value
V _{IN} range	-0.5 VDC to 60 VDC
Output power	56 W
Lead temperature	300 °C for 10 s
Operating temperature	–55 °C to 125 °C
Storage temperature	–55 °C to 125 °C
Shock	1500 gpk, 0.5 ms, ½ sine
Constant acceleration	50 g
Random vibration	24.06 grms, 50 Hz to 2000 Hz

4. Electrical Parameters

This section shows the electrical parameters of the SA50-28 Single Series device under the following conditions unless otherwise specified:

Parameter	Output	Conditions	Min	Nom	Max	Units
Input voltage						
(Vin)		Note 2	20	28	40	V
Output voltage						
	28V		27.73	28.00	28.27	
	15V		14.85	15.00	15.15	-
(V _{OUT})	12V	I _{OUT} = 100% rated load	11.88	12.00	12.12	V
	5V		5.05	5.10	5.15	
	3.3V		3.27	3.30	3.33	
Output Voltage Adjus	Output Voltage Adjust					
(V _{ADJ})			10			%
Output power						
	28V	Note 13 In all cases Output power must be kept within P _{out} rating.	0		56	
	15V				51	
(P _{OUT})	12V				50	W
	5V				50	
	3.3V				33	
Output current						
	28V				2.0	
	15V				3.4	
(I _{OUT})	12V		0		4.2	Α
	5V				10	
	3.3V				10	

continued						
Parameter	Output	Conditions	Min	Nom	Max	Units
Line regulation						
	28V		– 56		56	
	15V	V _{IN} = 20 V, 28 V, 40 V I _{OUT}	-30		30	
(VR _{LINE})	12V	= 10%, 50%, 100% rated Note	-24		24	mV
	5V		–10		10	
	3.3V		–10		10	
Load regulation						
	28V		-280		280	
	15V	V _{IN} = 20 V, 28 V, 40 V I _{OUT}	–150		150	
(VR _{LOAD})	12V	= 10%, 50%, 100% rated Note	-120		120	mV
	5V		_ 50		50	
	3.3V		– 50		50	
Input current						
(I _{IN})		I _{OUT} =0, pin3 open		100	150	mA
		Pin 3 shorted to pin 2		2	5	
Output ripple						
	28V			100	280	
	15V			75	150	
(V _{RIP})	12V	V _{IN} = 20 V, 28 V, 40 V I _{OUT} = 100% rated, Note 4		60	120	mV p-p
	5V			25	50	
	3.3V			25	50	
Switching frequency						
(FS)		Sync input (pin 4) open	200	220	240	kHz
Efficiency						
	28V		78	82		
	15V		77	82		
(EFF)	12V	I _{OUT} = 100% rated load	76	82		%
	5V		71	81		
	3.3V		62	79		

continued						
Parameter	Output	Conditions	Min	Nom	Max	Units
Inhibit input						
Inhibit input: ON Threshold		Note 1	4.5			V
Inhibit input: OFF drive current (sink)		Note 1	1000			μΑ
Inhibit input: OFF Threshold		Note 1			2	V
Current limit point						
(% rated output)		When V _{OUT} = 90% of nominal set point	105		145	%
Synchronization						
frequency range		The external clock on sync input (pin 4)	500		600	kHz
Synchronization pulse-high level		Note 1	4.0		10.0	V
Synchronization pulse-low level		Note 1	-0.5		0.5	V
Synchronization pulse-transition rate		Note 1	200			V/µs
Synchronization pulse-duty cycle		Note 1	10		80	%
Power dissipation, loa	ad fault					
(PD)		Short circuit, overload Note 6			24	W
Output response to step load changes						
	28V		-2200		2200	
	15V	(500/ 1-15 - 4000/)	-1200		1200	
(V _{TLD})	12V	(50% to/from 100%) rated load Note 7	-900		900	mV peak
	5V	14.54 1544 11010 1	-500		500	
	3.3V		-300		300	

Country time, step load changes	continued						
(T _{TLD})	Parameter	Output	Conditions	Min	Nom	Max	Units
Comparison Co	Recovery time, step I	oad change	s				
Notes 7, 8 Notes 8, 9 Notes 9, 9 No			(50% to/from 100%)				
Output response to step line changes 28V 15V -1000 1000 600 mV 600 600 mV pea -800 480 mV pea mV pea -300 300 mV pea -300 300 mV pea -300 300 mV -300 200 pea 200 pea 200 pea mV -300 mV	(T _{TLD})				200	2000	μs
28V			·				
15V 12V 20V to/from 40V I _{OUT} = 100% -600 -480 480 peal 300 300	Output response to s		nges		I	I	I
(V _{TLN})		28V		-1000		1000	
rated load Note 9 5V 3.3V -300 300 Recovery time, step line changes (T _{TLN}) 20V to/from 40V l _{OUT} = 100% rated load Notes 8, 9 200 2000 μs Turn-on response: overshoot (V _{OS}) (main) 12V 5V 3.3V (0% to 100%) rated load Notes 3, 4, 10 5V 3.3V Turn-on response: turn-on delay (T _{DLY}) Note 10 0.1 10 ms Capacitive load		15V	00)/1 / 40)/1	-600		600	.,
3.3V -300 300 -300 Recovery time, step line changes	(V _{TLN})	12V		-480		480	mv peak
Recovery time, step line changes 20V to/from 40V I _{OUT} = 100% rated load Notes 8, 9 200 2000 μs		5V		-300		300	
(T _{TLN}) 20V to/from 40V I _{OUT} = 100% rated load Notes 8, 9 200 2000 μs Turn-on response: overshoot 28V 2800 15V 1500 1500 1500 mV (V _{OS}) (main) 12V (0% to 100%) rated load Notes 3, 4, 10 1200 mV 5V 3.3V 500 500 Turn-on response: turn-on delay (T _{DLY}) Note 10 0.1 10 ms Capacitive load 28V 200 350		3.3V		-300		300	
Turn-on response: overshoot 28V	Recovery time, step I	ine changes	•				
28V 15V (0% to 100%) rated load 1200 mV 1500 1500 1200 mV 1500 1200 mV 1200 1200 mV 1200	(T _{TLN})				200	2000	μs
15V	Turn-on response: ov	vershoot					
(VOS) (main) 12V (0% to 100%) rated load Notes 3, 4, 10 1200 mV 5V 500 500 500 Turn-on response: turn-on delay (TDLY) Note 10 0.1 10 ms Capacitive load 28V 200 350 15V 350 350		28V				2800	
Notes 3, 4, 10 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1200 1100 1100 1200 1200		15V				1500	
5V 500 500	(V _{OS}) (main)	12V				1200	mV
Turn-on response: turn-on delay (T _{DLY}) Note 10 0.1 10 ms Capacitive load 28V 200 15V 350		5V				500	
(T _{DLY}) Note 10 0.1 10 ms Capacitive load 28V 200 350		3.3V				500	
Capacitive load 28V 200 15V 350	Turn-on response: tu	Turn-on response: turn-on delay					
28V 200 15V 350	(T _{DLY})		Note 10	0.1		10	ms
15V 350	Capacitive load						
		28V				200	
(CL) 12)/ Note 5		15V				350	
(OL) 12V NOTE 5 450 µF	(CL)	12V	Note 5			450	μF
5V 1000		5V				1000	
3.3V 1000							

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Electrical Parameters

continued	continued					
Parameter	Output	Conditions	Min	Nom	Max	Units
Line rejection						
		DC to 50 kHz, I _{OUT} = 100% rated load	30	60		dB
Isolation	'					
		50V @25°C 1. Input (1-3) to All (4-12) 2. Sync (4-5) to All (1-3, 6-12) 3. Chassis (6) to All (1-5, 7-12)	100			МΩ
Mass						
		Standard case style A, B		120		g
MTBF						
		MIL-HDBK-217F2, SF, 35°C		8.22x10 ⁶		hrs

5. Radiation Specification (Note 1)

Environment	Conditions	Min	Unit
TID (gamma)	MIL-STD-883, method 1019 The operating bias applied during exposure	100	krad (Si)
Dose rate (gamma dot temporary saturation survival)	MIL-STD-883, method 1023 The operating bias applied during exposure Full-rated load	1E10	rad (Si)/s
Neutron fluence	MIL-STD-883, 1017	1E12	Neutrons
SEE SEU, SEL, SEGR, SEB	Heavy ions [LET] The operating bias applied during exposure	82	MeV•cm²/mg

Notes:

- 1. Parameter not 100% tested, and only assured by design.
- 2. Parameter verified during line and load regulation tests. Regulation is specified for 10% to 100% loading on all outputs.
- 3. The "-H" option incorporates FET technology providing a > 82 MeV•cm2/mg (gold ion) SEE capability to the design. The "-P" option is not rated for radiation.
- 4. Tested and verified using a 20 kHz to 10 MHz bandwidth. Ripple is measured across a 50 Ohms termination with a 10nF Cap in series. Results applicable for DC to 20MHz bandwidth.
- 5. The capacitive load may be any value from 0 to the maximum limit without compromising DC performance. A capacitive load exceeding the maximum limit may interfere with the proper operation of the converter's overload protection, potentially causing erratic behavior during turn-on.
- 6. Overload power dissipation is defined as the device power dissipation with the load set such that

 V_{OUT} = 90% of nominal.

- 7. The load step transition time is $\ge 10 \ \mu s$.
- 8. Recovery time is measured from the initiation of the transient to where V_{OUT} has returned to within $\pm 1\%$ of its steady-state value.
- 9. The line step transition time is \geq 100 μ s.
- 10. Turn-on delay time from either a step application of input power or a logic low to a logic high transition on the inhibit pin (pin 3) to the point where V_{OUT} = 90% of nominal.
- 11. Load regulation relative to the output voltage at 50% of nominal rated load.
- 12. Line regulation relative to the output voltage at 28 VDC input.
- 13. For operation at temperatures between 85 °C and 125 °C: de-rate power linearly from 50 W (or rated maximum) to zero. Parameter limits are not guaranteed.

Parallel Operation (Notes)

6. Parallel Operation (Notes)

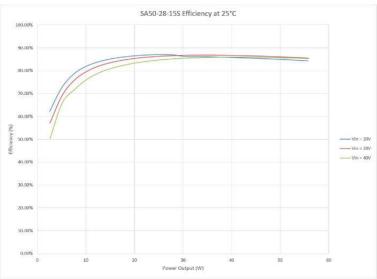
The output terminals of up to 5 modules may be connected in parallel. The expected current sharing accuracy is 10% at maximum load. To ensure current sharing, the Parallel terminal of every Power Supply module must be connected to form a common bus. These connections should be made relatively short.

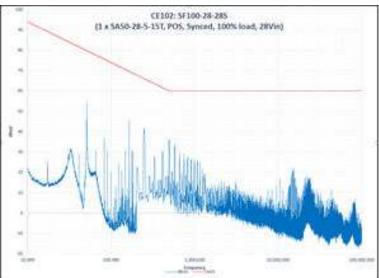
The remote sense terminals may remain unconnected. For best output voltage regulation however, the remote sense terminal of each of the paralleled set of Power Supplies should be connected to a single point, as close as possible to the positive load terminal or point where the voltage regulation is desired to be maintained. Similarly, the remote sense return terminal of each Power Supply should be connected to a single point, as close as possible to the negative load terminal.

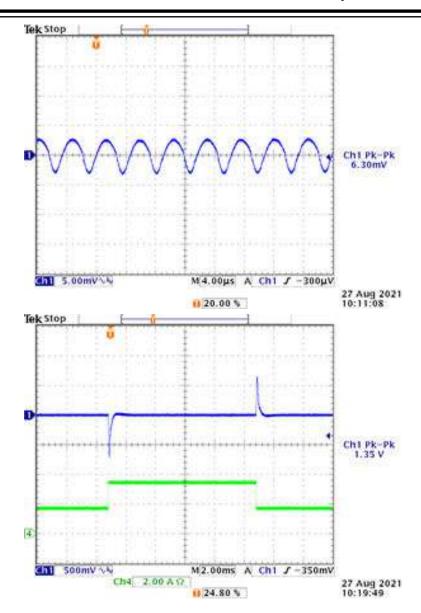
The R-ADJUST function may be used in a system of paralleled modules. The sync function is described in the application notes. The specified sync input signal may be applied to each of the paralleled modules.

For best performance, phase shift the sync signal between modules. The sync functionality remains the same for a system of paralleled modules. The use of the sync function is optional for single and or paralleled operation. The specified sync input signal may be applied to any one of the paralleled modules.

7. Sample Electrical Waveforms







8. Pin Configuration

Figure 8-1. SA50-28 Single Pin Configuration



9. Pin Description

PIN	NAME	Description
1	VIN	Input Voltage
2	VIN RTN	Input Voltage Return/Ground
3	ON/OFF (INHIBIT)	Power Supply ON/OFF, ON(OPEN/HIGH), OFF(SHORT/LOW)
4	SYNC	External Clock Signal Input
5	SYNC RTN	External Clock Signal Return
6	CHASSIS	Chassis Pin
7	R-ADJUST	Remote Adjust Pin to Adjust Output Voltage ±10%
8	PARALLEL	Parallel Bus Pin to use Multiple Devices for Higher Power
9	RMT SNS RTN	Load Voltage Remote Sense Return
10	RMT SNS	Load Voltage Remote Sense
11	VOUT	Output Voltage
12	VOUT RTN	Output Voltage Return/Ground

10. **Radiation Performance (-H) Hardened**

- TID>100krad(Si) and 30krad(Si) ELDRS (<10mrad/s) per MIL-STD-883 Method 1019
- SEE (SEGR, SEB, SET, SEL) immunity 82 MeV·cm²/mg (H-hardened)

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Radiation Performance (-P)

11. **Radiation Performance (-P)**

Prototype units that are functionally the same. The components are not radiation hardened. To be used for system checkout.

12. Mechanical Outline (-A) Package

Figure 12-1. Axial Pins and Thru-hole Tabs Package

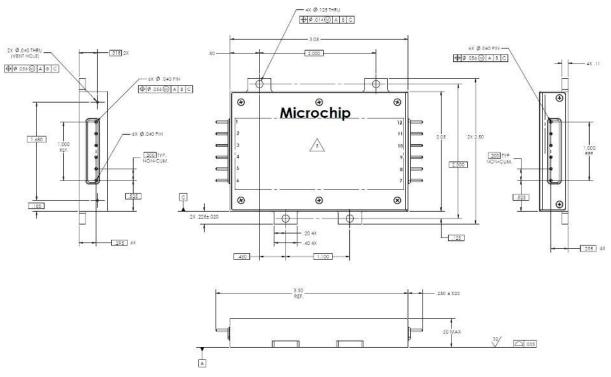
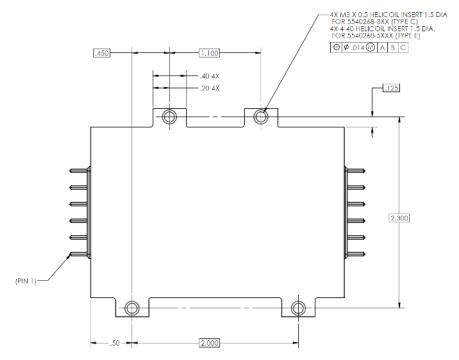


Figure 12-2. Axial Pins and Thru-hole Tabs Bottom View



13. Mechanical Outline (-B) Package

Figure 13-1. Radial Pins and Threaded Tabs Package (-C or -E)

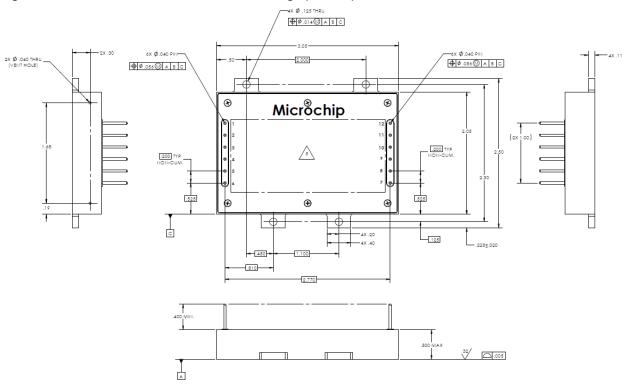
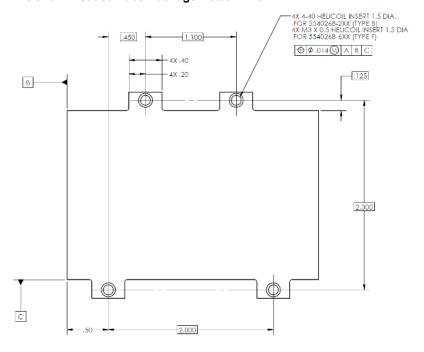


Figure 13-2. Radial Pins and Threaded Tabs Package Bottom View



14. Qualification Test (Reference Report QTR996)

Test	Conditions
External visual	Per O&M—dimensions, and mass
	or STD 883 2009
Electrical	Read and record (–55 °C, 25 °C, 85 °C)
Shock, non-operating	MIL-STD-202, method 213B, test condition F, 1500 gpk, 0.5 ms ½ sine pulse.
	Three pulses in each direction of each axis, 18 pulses total.
Vibration, operating	MIL-STD-202, method 214A, condition II-F, 24.06 grms random vibrations, 50 Hz–2000 Hz, 3 min/axis (9 min total).
	Outputs monitored.
Temperature cycling	10 cycles from base plate temperature, MIL-STD-883, method 1010.9, condition A
ЕМІ	CE101, CE102, CS101, CS106, RE101, RE102, RS101, RS102 per MIL- STD-461 with setup per MIL-STD-462.
External	No damage
Visual inspection	
Steady state life test	1000 hrs at Tc = 105 °C, 50% of rated load
End-point electricals	Read and record (–55 °C, 25 °C, 85 °C)

15. ATP Screening Test (-H) Hardened

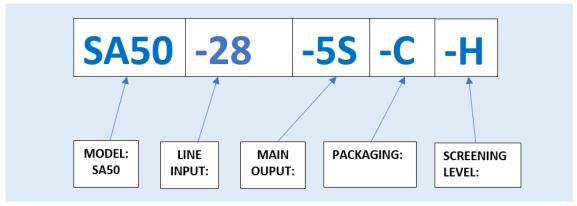
Requirement	Test Method/Condition
External Visual	O&M – dimensions and mass
Initial Electrical	Full performance at +25°C
Vibration	Workmanship non-operating vibration MIL-STD-202, Method 214, 6 grms (50Hz-2kHz) 1-minute perpendicular to the board
Post Vibration Electrical	Full performance at +25°C
Temperature Cycle	MIL-STD-883, Method 1010, Condition A, 1 cycle, +85°C to -55°C, operating. Outputs monitored during thermal cycles
Burn-in	40 Hrs @ 105°C, 50% of rated load (outputs monitored)
Final Electrical	Full performance at +25°C (deliverable data)
External Visual	No damage

ATP Screening Test (-P) Prototypes

16. ATP Screening Test (-P) Prototypes

Requirement	Test Method/Condition			
External Visual	O&M – dimensions and mass			
Electrical	Full performance at +25°C			
Vibration	None			
Temperature Cycle	None			
Burn-in	None			
External Visual	No damage			

17. Ordering Information



Model	SA50	Standard Applications 50W, 28V input modules.			
Line Input	-28	28.0V	Line input voltage. Nominal input line		
Main	-3R3S	3.3V			
	-5S	5V			
	-128	12V	Main output voltage		
	-15S	15V			
	-28S	28V			
Mechanical Package	-A	Axial	0.125in thru-hole	Mechanical packaging options.	
	-B	Radial	4-40 thread		
	-C	Axial	M3 thread	Electrical connections are either Axial or the Radial. And mounting holes are drilled thru-hole or	
	-D	Radial	0.125in thru-hole		
	-E	Axial	4-40 thread	threaded.	
	-F	Radial	M3 thread		
Radiation Hardness	-H	Hardened	We offer units with two levels of radiation screening. Hardened and Prototype (non-hardened) units.		
	-P	Prototype			

NOTE: Other input voltage and output voltage combinations are available. Please contact your local sales representative.

We also offer a thermal interface, the ST-2X3; this is a non-silicon, space-approved thermal interface. Datasheet available upon request.

Revision History 18.

Revision	Date	Description
D	07/2022	Updated Electrical information in the ATP Screening Test (-P) Prototypes table.
С	04/2022	Updated the Max "Current Limit Point" to 145 in the Electrical Parameters. Updated Figure 13-1.

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ISBN: 978-1-6683-0914-8

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