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 $8.22x10^6$ hours of MTBF.

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

Table of Contents

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

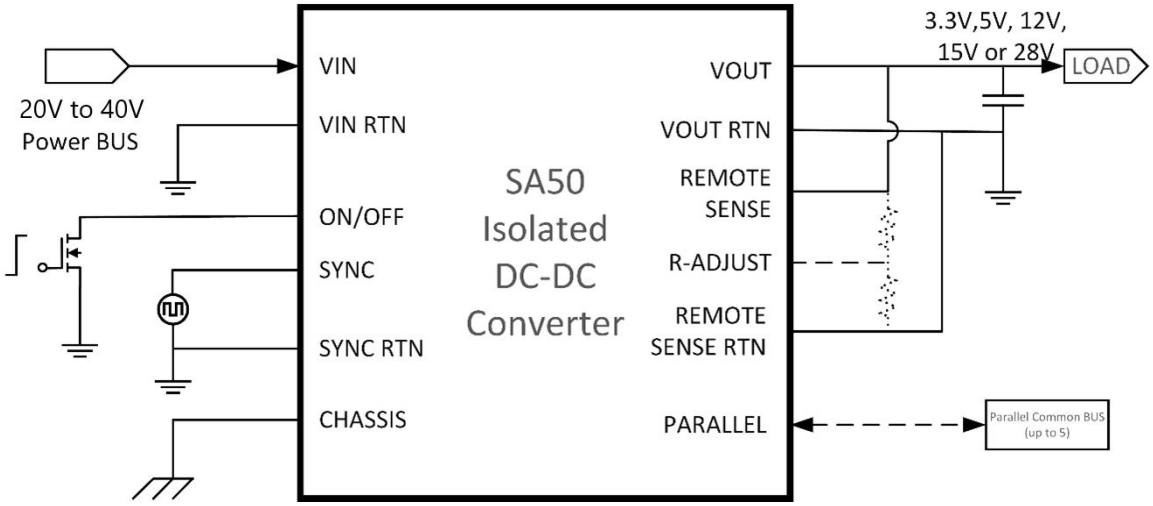
- Up to 82% efficiency @ full load
- <1% output ripple
- Forward topology
- Patented magnetic feedback
- Adjustable output with remote adjust
- Inhibit pin for electrical ON/OFF
- Capable of paralleling up to 5 identical units.
- Isolated synchronization input
- Low mass 120g
- Flight proven technology with >8 x 10^6 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·cm^2/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						
(V_{OUT})	28V	I_{OUT} = 100% rated load	27.73	28.00	28.27	V
	15V		14.85	15.00	15.15	
	12V		11.88	12.00	12.12	
	5V		5.05	5.10	5.15	
	3.3V		3.27	3.30	3.33	
Output Voltage Adjust						
(V_{ADJ})			10			%
Output power						
(P_{OUT})	28V	Note 13 In all cases Output power must be kept within P_{out} rating.	0		56	W
	15V				51	
	12V				50	
	5V				50	
	3.3V				33	
Output current						
(I_{OUT})	28V		0		2.0	A
	15V				3.4	
	12V				4.2	
	5V				10	
	3.3V				10	

.....continued

Parameter	Output	Conditions	Min	Nom	Max	Units
Line regulation						
(VR_{LINE})	28V	V_{IN} = 20 V, 28 V, 40 V I_{OUT} = 10%, 50%, 100% rated Note 12	–56		56	mV
	15V		–30		30	
	12V		–24		24	
	5V		–10		10	
	3.3V		–10		10	
Load regulation						
(VR_{LOAD})	28V	V_{IN} = 20 V, 28 V, 40 V I_{OUT} = 10%, 50%, 100% rated Note 11	–280		280	mV
	15V		–150		150	
	12V		–120		120	
	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						
(V_{RIP})	28V	V_{IN} = 20 V, 28 V, 40 V I_{OUT} = 100% rated, Note 4		100	280	mV p-p
	15V			75	150	
	12V			60	120	
	5V			25	50	
	3.3V			25	50	
Switching frequency						
(FS)		Sync input (pin 4) open	200	220	240	kHz
Efficiency						
(EFF)	28V	I_{OUT} = 100% rated load	78	82		%
	15V		77	82		
	12V		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			µA
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, load fault						
(PD)		Short circuit, overload Note 6			24	W
Output response to step load changes						
(V_{TLD})	28V	(50% to/from 100%) rated load Note 7	–2200		2200	mV peak
	15V		–1200		1200	
	12V		–900		900	
	5V		–500		500	
	3.3V		–300		300	

.....continued

Parameter	Output	Conditions	Min	Nom	Max	Units
Recovery time, step load changes						
(T_{TLD})		(50% to/from 100%) rated load Notes 7, 8		200	2000	µs
Output response to step line changes						
(V_{TLN})	28V	20V to/from 40V I_{OUT} = 100% rated load Note 9	–1000		1000	mV peak
	15V		–600		600	
	12V		–480		480	
	5V		–300		300	
	3.3V		–300		300	
Recovery time, step line changes						
(T_{TLN})		20V to/from 40V I_{OUT} = 100% rated load Notes 8, 9		200	2000	µs
Turn-on response: overshoot						
(V_{OS}) (main)	28V	(0% to 100%) rated load Notes 3, 4, 10			2800	mV
	15V				1500	
	12V				1200	
	5V				500	
	3.3V				500	
Turn-on response: turn-on delay						
(T_{DLY})		Note 10	0.1		10	ms
Capacitive load						
(CL)	28V	Note 5			200	µF
	15V				350	
	12V				450	
	5V				1000	
	3.3V				1000	

.....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			MΩ
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•cm^2/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 ≥ 10 µs.

8. Recovery time is measured from the initiation of the transient to where V_{OUT} has returned to within ±1% of its steady-state value.

9. The line step transition time is ≥ 100 µs.

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.

6. Parallel Operation (Notes)

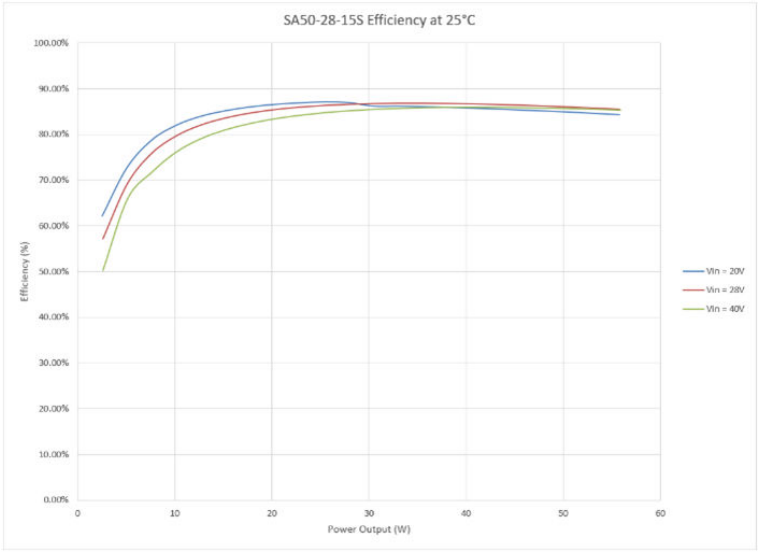
The output terminals of up to 5 modules may be connected in parallel. The expected current sharing accuracy is 10% at maximum load. To ensure current sharing, the Parallel terminal of every Power Supply module must be connected to form a common bus. These connections should be made relatively short.

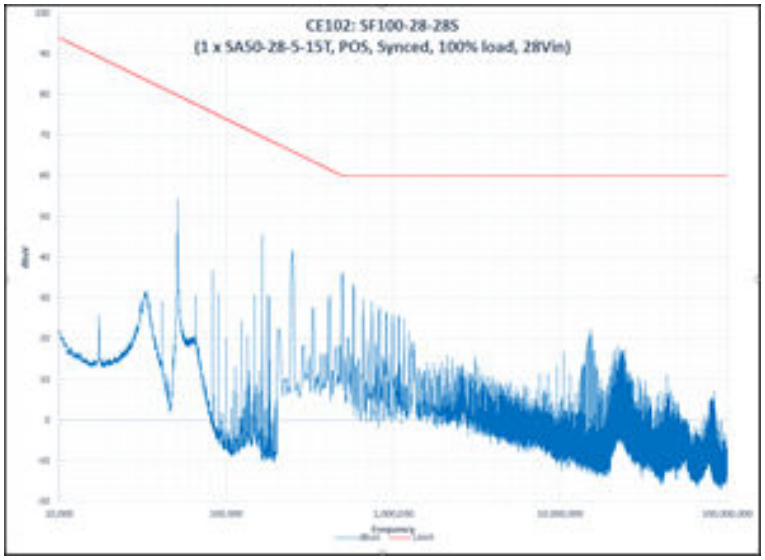
The remote sense terminals may remain unconnected. For best output voltage regulation however, the remote sense terminal of each of the paralleled set of Power Supplies should be connected to a single point, as close as possible to the positive load terminal or point where the voltage regulation is desired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

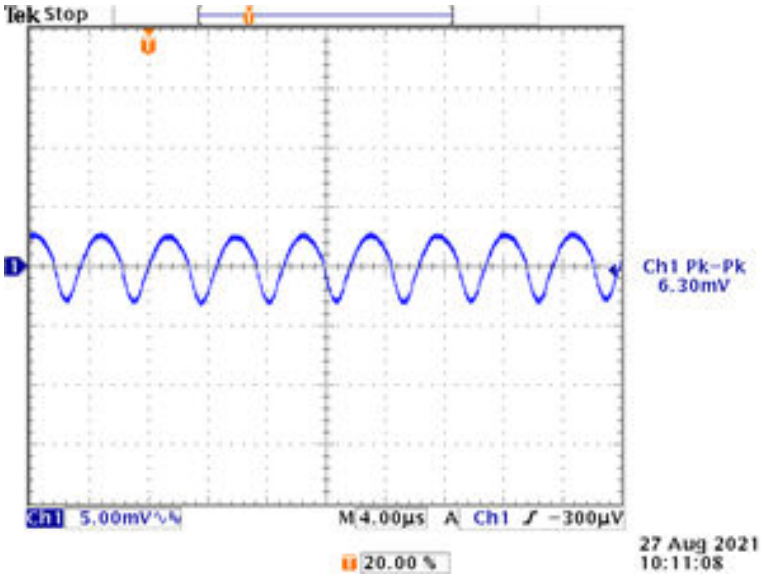
The R-ADJUST function may be used in a system of paralleled modules. The sync function is described in the application notes. The specified sync input signal may be applied to each of the paralleled modules.

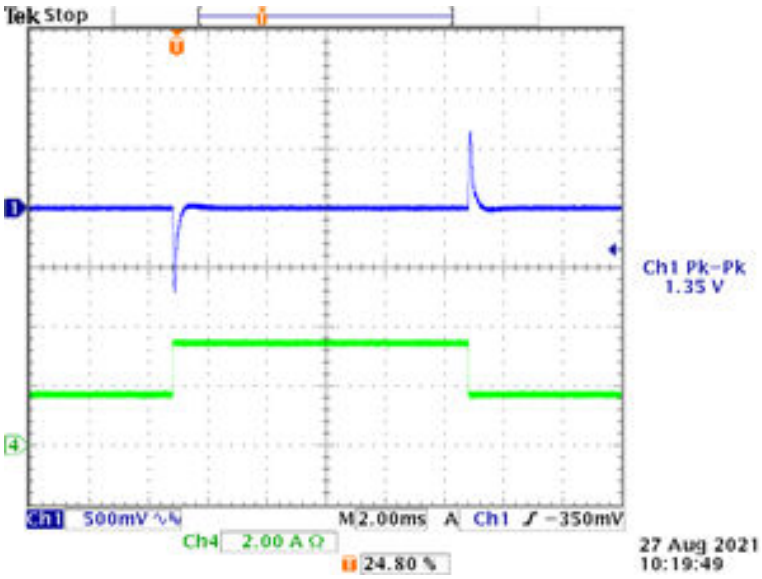
For best performance, phase shift the sync signal between modules. The sync functionality remains the same for a system of paralleled modules. The use of the sync function is optional for single and or paralleled operation. The specified sync input signal may be applied to any one of the paralleled modules.

7. Sample Electrical Waveforms






Tek Stop
Ch1 Pk-Pk
6.30mV
Ch1 5.00mV
M 4.00µs A Ch1 ƒ -300µV
20.00 %
27 Aug 2021
10:11:08


Tek Stop
Ch1 Pk-Pk
1.35 V
Ch1 500mV
M 2.00ms A Ch1 ƒ -350mV
Ch4 2.00 A Ω
24.80 %
27 Aug 2021
10:19:49

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·cm^2/mg (H-hardened)

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

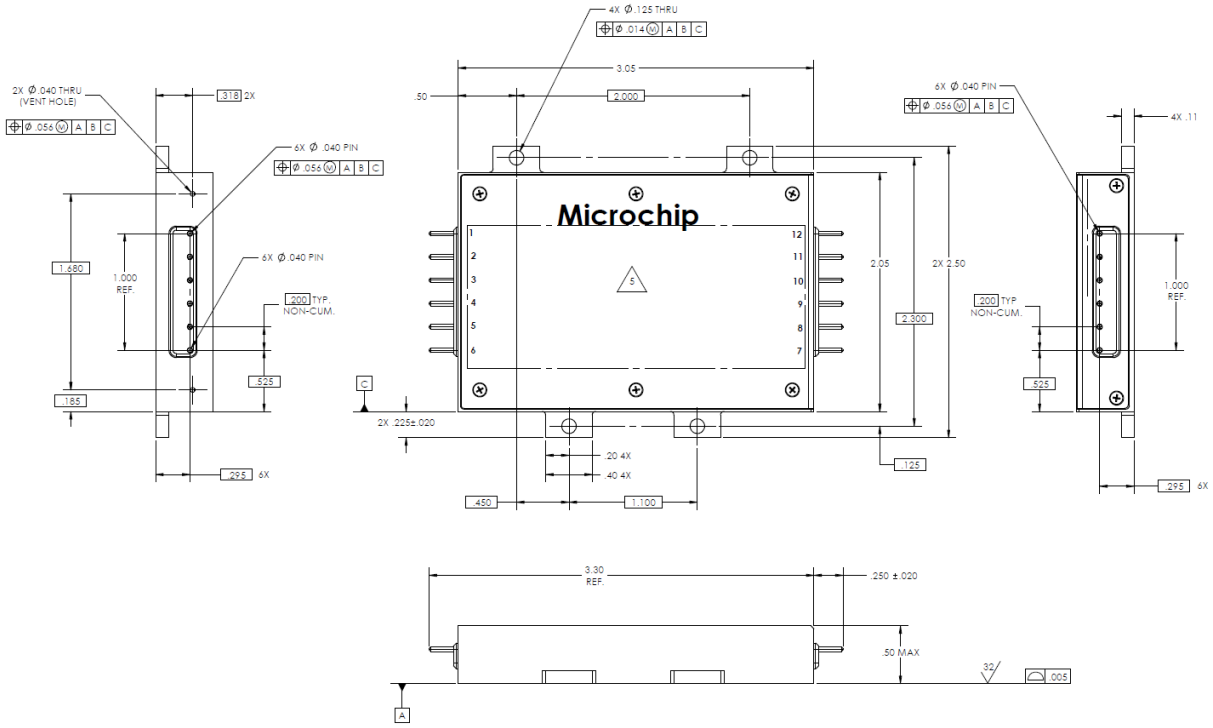
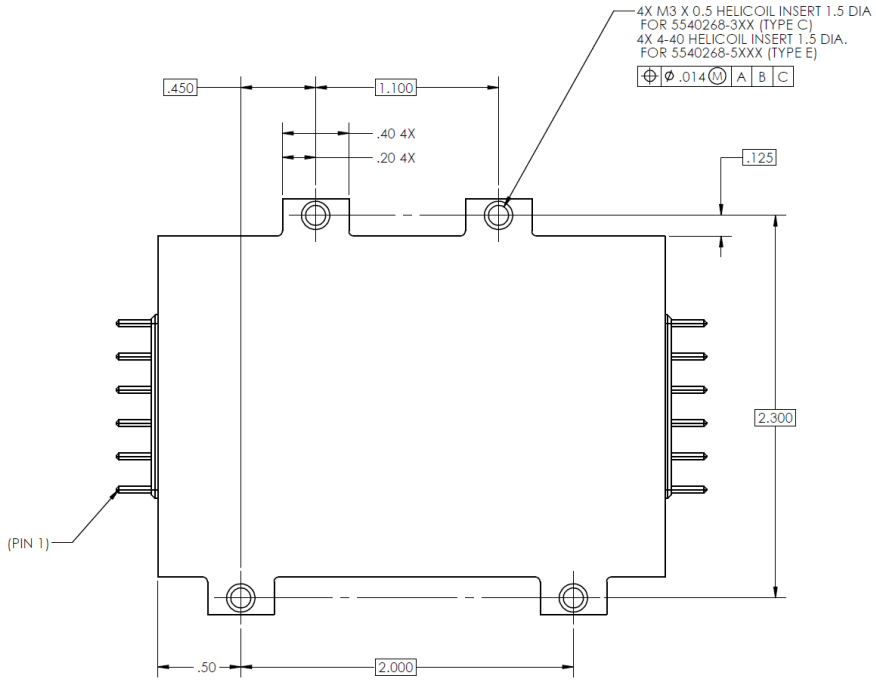


Figure 12-2. Axial Pins and Thru-hole Tabs Bottom View



13. Mechanical Outline (-B) Package

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

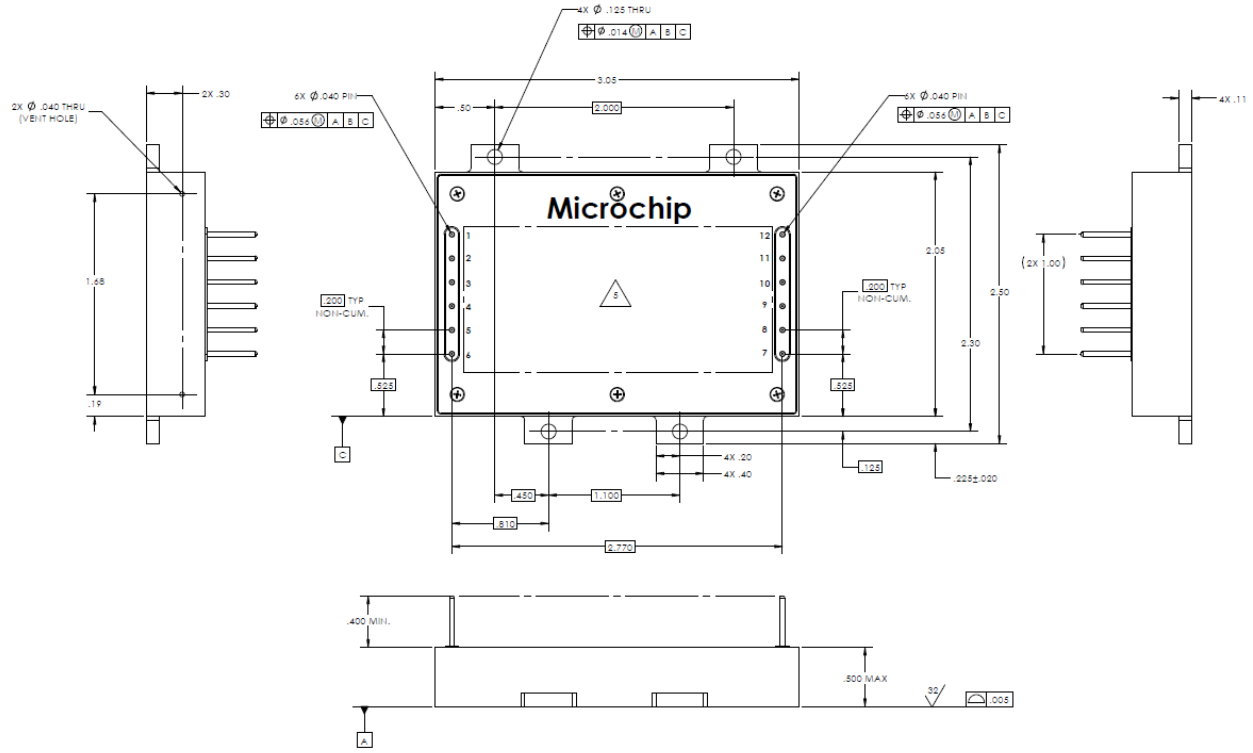
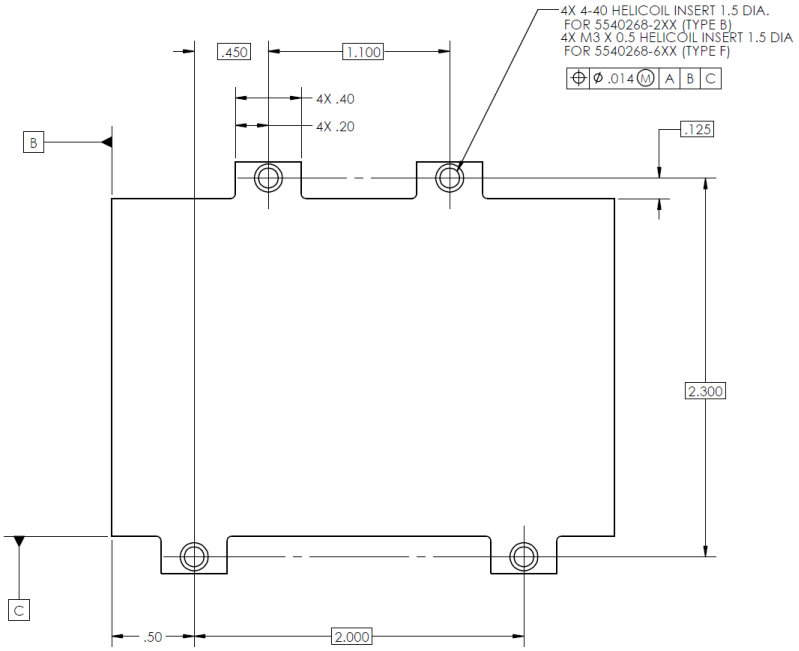


Figure 13-2. Radial Pins and Threaded Tabs Package Bottom View



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
EMI	CE101, CE102, CS101, CS106, RE101, RE102, RS101, RS102 per MIL-STD-461 with setup per MIL-STD-462.
External Visual inspection	No damage
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)

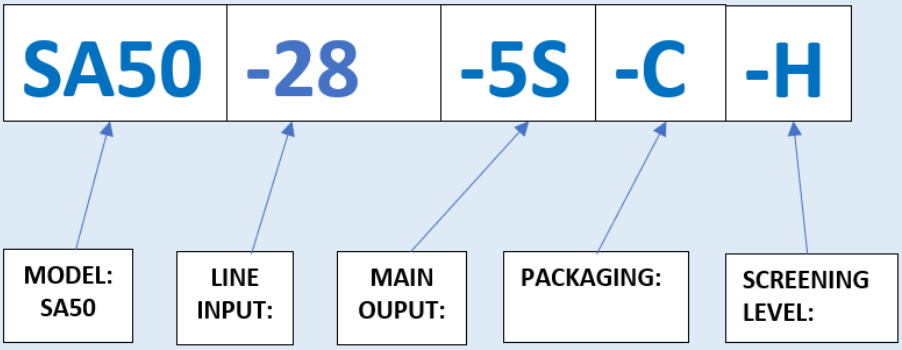
15. ATP Screening Test (-H) Hardened

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

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	Main output voltage	
	-5S	5V		
	-12S	12V		
	-15S	15V		
	-28S	28V		
Mechanical Package	-A	Axial	0.125in thru-hole	Mechanical packaging options. Electrical connections are either Axial or the Radial. And mounting holes are drilled thru-hole or threaded.
	-B	Radial	4-40 thread	
	-C	Axial	M3 thread	
	-D	Radial	0.125in thru-hole	
	-E	Axial	4-40 thread	
	-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.

18. Revision History

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

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable". Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

Trademarks

ISBN: 978-1-6683-0914-8

Quality Management System

For information regarding Microchip’s Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: www.microchip.com/support Web Address: www.microchip.com **Atlanta** Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455 **Austin, TX** Tel: 512-257-3370 **Boston** Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088 **Chicago** Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075 **Dallas** Addison, TX Tel: 972-818-7423 Fax: 972-818-2924 **Detroit** Novi, MI Tel: 248-848-4000 **Houston, TX** Tel: 281-894-5983 **Indianapolis** Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380 **Los Angeles** Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800 **Raleigh, NC** Tel: 919-844-7510 **New York, NY** Tel: 631-435-6000 **San Jose, CA** Tel: 408-735-9110 Tel: 408-436-4270 **Canada - Toronto** Tel: 905-695-1980 Fax: 905-695-2078	**Australia - Sydney** Tel: 61-2-9868-6733 **China - Beijing** Tel: 86-10-8569-7000 **China - Chengdu** Tel: 86-28-8665-5511 **China - Chongqing** Tel: 86-23-8980-9588 **China - Dongguan** Tel: 86-769-8702-9880 **China - Guangzhou** Tel: 86-20-8755-8029 **China - Hangzhou** Tel: 86-571-8792-8115 **China - Hong Kong SAR** Tel: 852-2943-5100 **China - Nanjing** Tel: 86-25-8473-2460 **China - Qingdao** Tel: 86-532-8502-7355 **China - Shanghai** Tel: 86-21-3326-8000 **China - Shenyang** Tel: 86-24-2334-2829 **China - Shenzhen** Tel: 86-755-8864-2200 **China - Suzhou** Tel: 86-186-6233-1526 **China - Wuhan** Tel: 86-27-5980-5300 **China - Xian** Tel: 86-29-8833-7252 **China - Xiamen** Tel: 86-592-2388138 **China - Zhuhai** Tel: 86-756-3210040	**India - Bangalore** Tel: 91-80-3090-4444 **India - New Delhi** Tel: 91-11-4160-8631 **India - Pune** Tel: 91-20-4121-0141 **Japan - Osaka** Tel: 81-6-6152-7160 **Japan - Tokyo** Tel: 81-3-6880- 3770 **Korea - Daegu** Tel: 82-53-744-4301 **Korea - Seoul** Tel: 82-2-554-7200 **Malaysia - Kuala Lumpur** Tel: 60-3-7651-7906 **Malaysia - Penang** Tel: 60-4-227-8870 **Philippines - Manila** Tel: 63-2-634-9065 **Singapore** Tel: 65-6334-8870 **Taiwan - Hsin Chu** Tel: 886-3-577-8366 **Taiwan - Kaohsiung** Tel: 886-7-213-7830 **Taiwan - Taipei** Tel: 886-2-2508-8600 **Thailand - Bangkok** Tel: 66-2-694-1351 **Vietnam - Ho Chi Minh** Tel: 84-28-5448-2100	**Austria - Wels** Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 **Denmark - Copenhagen** Tel: 45-4485-5910 Fax: 45-4485-2829 **Finland - Espoo** Tel: 358-9-4520-820 **France - Paris** Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79 **Germany - Garching** Tel: 49-8931-9700 **Germany - Haan** Tel: 49-2129-3766400 **Germany - Heilbronn** Tel: 49-7131-72400 **Germany - Karlsruhe** Tel: 49-721-625370 **Germany - Munich** Tel: 49-89-627-144-0 Fax: 49-89-627-144-44 **Germany - Rosenheim** Tel: 49-8031-354-560 **Israel - Ra'anana** Tel: 972-9-744-7705 **Italy - Milan** Tel: 39-0331-742611 Fax: 39-0331-466781 **Italy - Padova** Tel: 39-049-7625286 **Netherlands - Drunen** Tel: 31-416-690399 Fax: 31-416-690340 **Norway - Trondheim** Tel: 47-72884388 **Poland - Warsaw** Tel: 48-22-3325737 **Romania - Bucharest** Tel: 40-21-407-87-50 **Spain - Madrid** Tel: 34-91-708-08-90 Fax: 34-91-708-08-91 **Sweden - Gothenberg** Tel: 46-31-704-60-40 **Sweden - Stockholm** Tel: 46-8-5090-4654 **UK - Wokingham** Tel: 44-118-921-5800 Fax: 44-118-921-5820