# SA50-120 Single Series

## Radiation-Hardened Isolated DC-to-DC Converter

## Introduction

The SA50 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 scheme, the SA50 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.

The SA50 series implements an internal EMI input filter which complies to MIL-STD-461. The EMI filter consists of differential- and common-mode components to attenuate conductive EMI noise effectively.

As the only non-hybrid space grade DC-DC power converter module in the market, the SA50 series excels in its robustness in the applications with $8x10^6$ hours of MTBF.

The SA50-120 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)
- 86VDC to 158VDC input range
- 5 output configurations available

| Output | Base Part number |
|---|---|
| 3.3V | SA50-120-3R3S |
| 5V | SA50-120-5S |
| 12V | SA50-120-12S |
| 15V | SA50-120-15S |
| 28V | SA50-120-28S |

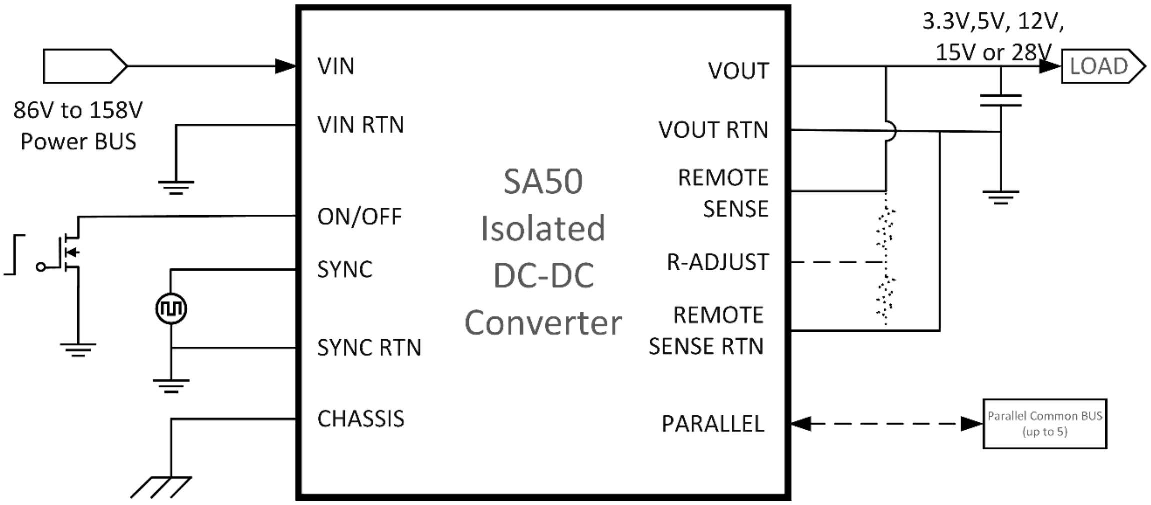
- 85% efficiency @ full load
- <1% output ripple
- Internal EMI filter compliant to MIL-STD-461
- Forward topology
- Patented magnetic feedback
- Adjustable output with remote adjust
- Inhibit pin for electrical ON/OFF
- Isolated synchronization input
- Low mass of less than 120g
- Flight proven technology with >8 x $10^6$ hours of MTBF
- This Product is classified as EAR99

# 2. 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

# 3. Typical Application circuit

**Figure 3-1. SA50 Single Typical Application Circuit**



# 4. Absolute Maximum Ratings

| Rating | Value |
|---|---|
| $V_{IN}$ range | –0.5 VDC to 165 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 $g_{rms}$, 50 Hz to 2000 Hz |

# 5. Electrical Parameters

This section shows the electrical parameters of the SA50-120 Single Series device under the following conditions unless otherwise specified:

| Parameter | Output | Conditions | Min | Nom | Max | Units |
|---|---|---|---|---|---|---|
| **Input voltage** | | | | | | |
| (Vin) | | Note 2 | 86 | 120 | 158 | V |
| **Output voltage set point** | | | | | | |
| ($V_{OUT}$) | 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<br>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 | |
| **Line regulation** | | | | | | |
| ($VR_{LINE}$) | 28V | $V_{IN}$ = 86 V, 120 V, 158 V<br>$I_{OUT}$ = 10%, 50%, 100% rated Note 12 | –56 | | 56 | mV |
| | 15V | | –30 | | 30 | |
| | 12V | | –24 | | 24 | |
| | 5V | | –10 | | 10 | |
| | 3.3V | | –10 | | 10 | |

**...........continued**

| Parameter | Output | Conditions | Min | Nom | Max | Units |
|---|---|---|---|---|---|---|
| **Load regulation** | | | | | | |
| ($VR_{LOAD}$) | 28V | $V_{IN}$ = 86 V, 120 V, 158 V<br>$I_{OUT}$ = 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 | | 10 | 35 | mA |
| | | Pin 3 shorted to pin 2 | | 3 | 5 | |
| **Output ripple** | | | | | | |
| ($V_{RIP}$) | 28V | $V_{IN}$ = 86 V, 120 V, 158 V<br>$I_{OUT}$ = 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 | 79 | 85 | | % |
| | 15V | | 79 | 85 | | |
| | 12V | | 77 | 83 | | |
| | 5V | | 75 | 81 | | |
| | 3.3V | | 73 | 79 | | |
| **Inhibit input** | | | | | | |
| Inhibit input: ON Threshold | | Note 1 | 4.5 | | | V |
| Inhibit input: OFF (sink) | | Note 1 | 1000 | | | µA |
| Inhibit input: OFF Threshold | | Note 1 | | | 2 | V |

| ...........continued | | | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Output** | **Conditions** | **Min** | **Nom** | **Max** | **Units** |
| **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<br>Note 6 | | | 24 | W |
| **Output response to step load changes** | | | | | | |
| ($V_{TLD}$) | 28V | (50% to/from 100%)<br>rated load Note 7 | –2200 | | 2200 | mV peak |
| | 15V | | –1200 | | 1200 | |
| | 12V | | –900 | | 900 | |
| | 5V | | –300 | | 300 | |
| | 3.3V | | –300 | | 300 | |
| **Recovery time, step load changes** | | | | | | |
| ($T_{TLD}$) | | (50% to/from 100%)<br>rated load<br>Notes 7, 8 | | 200 | 2000 | µs |
| **Output response to step line changes** | | | | | | |
| ($V_{TLN}$) | 28V | 86V to/from 158V $I_{OUT}$ = 100% rated load Note 9 | –1000 | | 1000 | mV peak |
| | 15V | | –600 | | 600 | |
| | 12V | | –480 | | 480 | |
| | 5V | | –300 | | 300 | |
| | 3.3V | | –300 | | 300 | |

**...........continued**

| Parameter | Output | Conditions | Min | Nom | Max | Units |
|---|---|---|---|---|---|---|
| **Recovery time, step line changes** | | | | | | |
| ($T_{TLN}$) | | 86V to/from 158V $I_{OUT}$ = 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 | |
| **Line rejection** | | | | | | |
| | | DC to 50 kHz, $I_{OUT}$ = 100% rated load | 30 | 60 | | dB |
| **Isolation** | | | | | | |
| | | 200V @25°C<br>1. Input (1-3) to All (4-12)<br>2. Sync (4-5) to All (1-3, 6-12)<br>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 | | 8.22E+06 | | hrs |

## 6. 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<br>(H – Hardened) | Heavy ions [LET] The operating bias applied during exposure | 82 | MeV•cm$^2$/mg |

Notes:

1. Parameter guaranteed by design.

2. Parameter verified during line and load regulation tests. Regulation is specified for 10% to 100% loading on all outputs.

3. The "–HS/–HE" 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. Guaranteed for a DC to 20 MHz bandwidth. Tested using a 20 kHz to 10 MHz bandwidth. Ripple is measured across a 50 Ohms termination with a 10nF Cap in series.

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. This situation may cause erratic behavior during turn-on.

6. Overload power dissipation is defined as the device power dissipation with the load set such that

VOUT = 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 VOUT 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 VOUT = 90% of nominal.

11. Load regulation relative to the output voltage at 50% rated load.

12. Line regulation relative to the output voltage at 120 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.

# 7. 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.

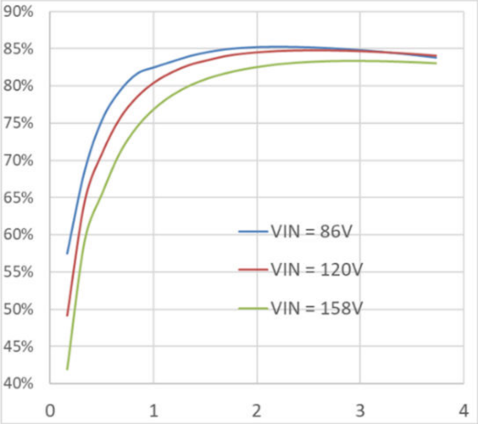
The remote sense terminals may remain unconnected. For best output voltage regulation however, the remote sense terminal of each of the paralleled set of Power Supplies should be connected to a single point, as close as possible to the positive load terminal or point where the voltage regulation is desired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

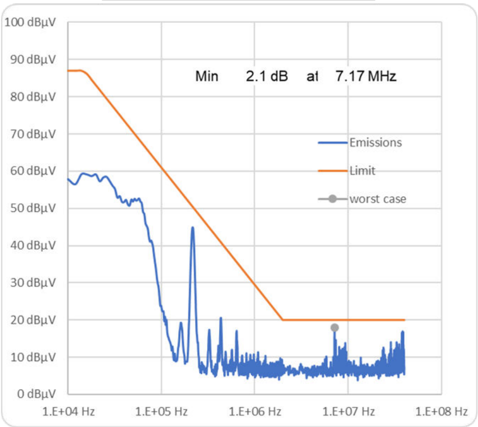
For best performance, phase shift the sync signal between modules. The sync functionality remains the same for a system of paralleled modules. The use of the sync function is optional for single and or paralleled operation. The specified sync input signal may be applied to any one of the paralleled modules.

## 8. Sample Electrical Waveforms

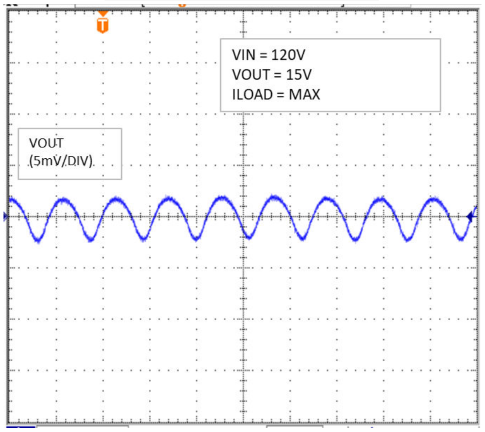
Efficiency Curve



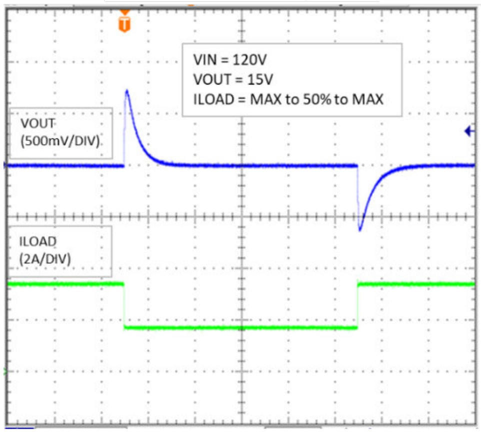
EMI Charcterization



Output Voltage Ripple



Load Transient Response



# 9. Pin Configuration

**Figure 9-1. SA50 Single Pin Configuration**

# 10. 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 |

# 11. 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)

# 12. Radiation Performance (-P) Prototype

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

## 13. Mechanical Outline (-A) Package

**Figure 13-1. Side Pins and Thru-Hole Tabs Package**

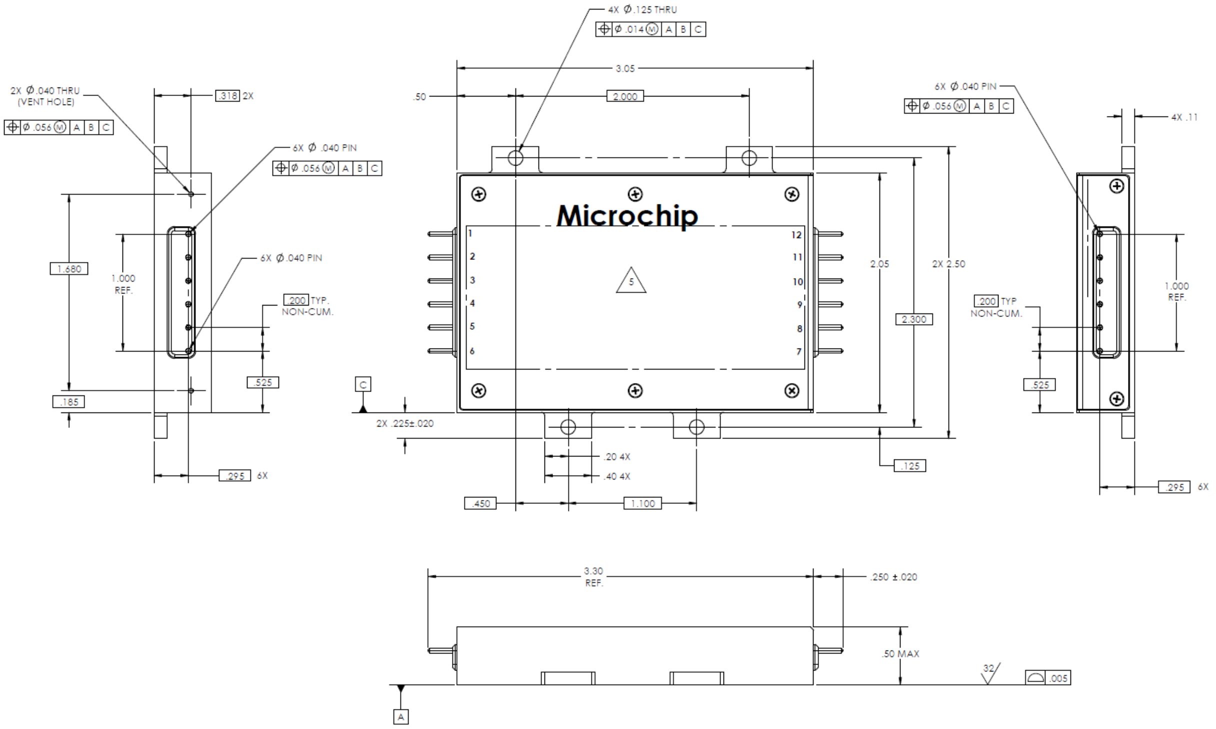
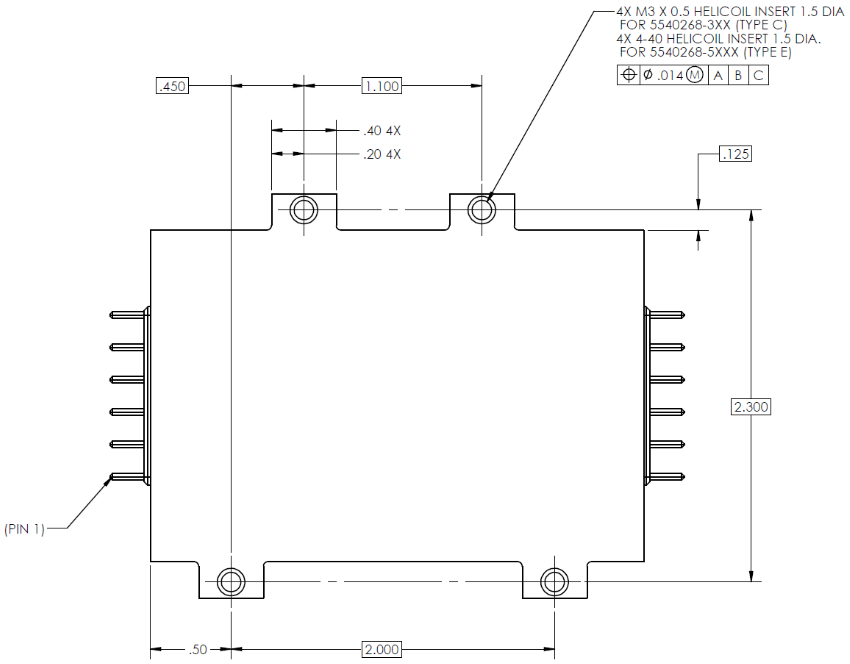


**Figure 13-2. Side Pins and Thru-Hole Tabs Bottom View**



# 14. Mechanical Outline (-B) Package

Figure 14-1. Top Pins and Threaded Package

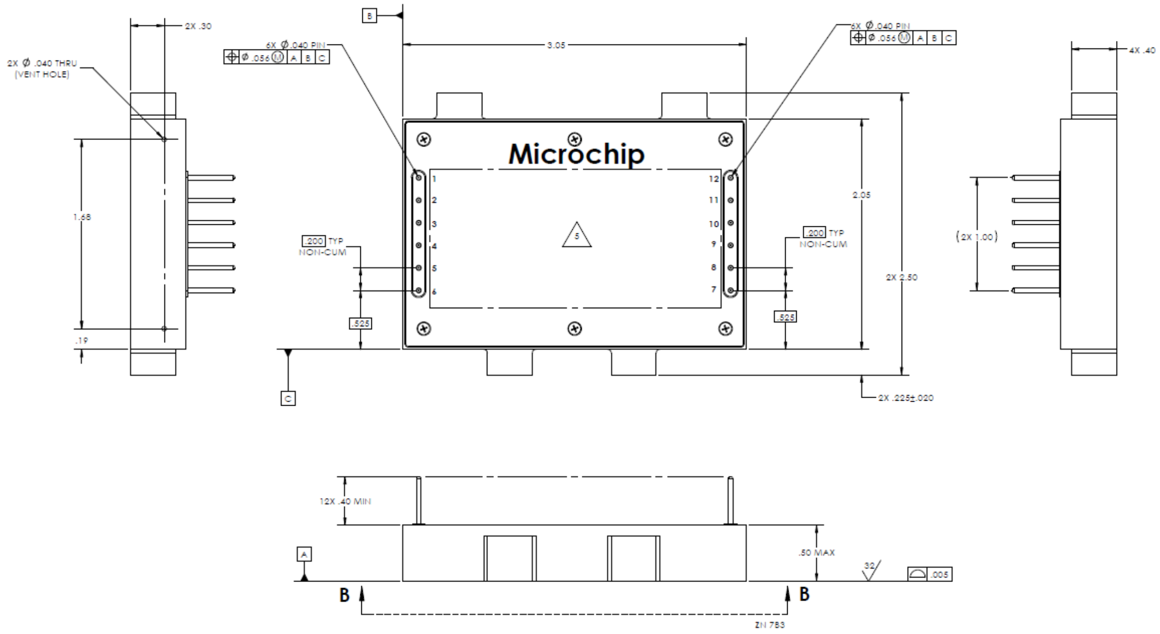
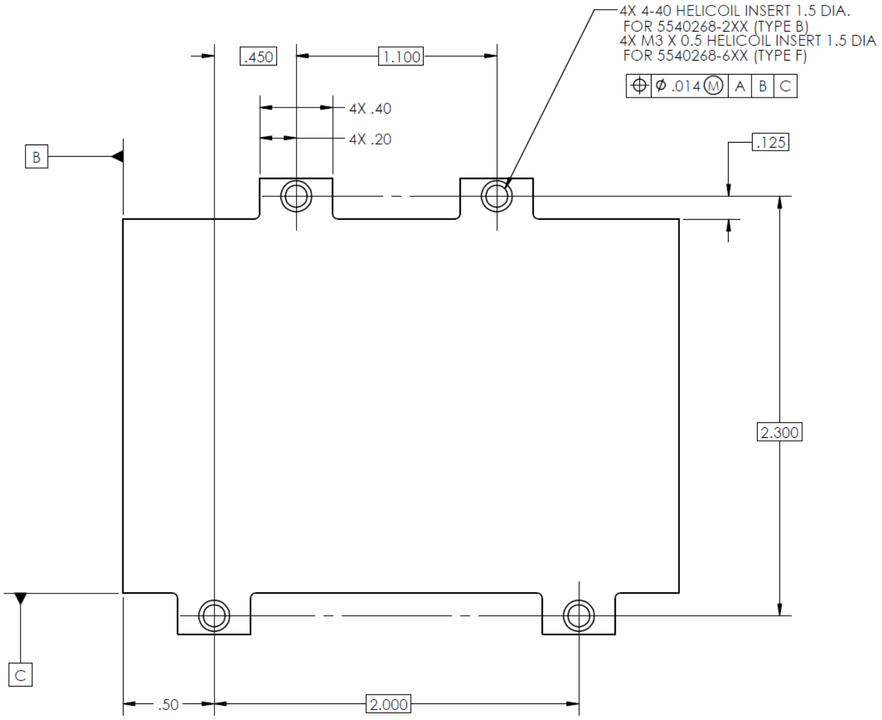


Figure 14-2. Top Pins and Threaded Package Bottom View



## 15. Qualification Test (Reference Report QTR996)

| Test | Conditions | Method | Notes |
|---|---|---|---|
| External visual | Per O&M—dimensions, and mass<br>or STD 883 2009 | Inspection | Appendix A |
| Electrical | Read and record (–55 °C, 25 °C, 85 °C) | Test | Appendix D |
| Shock, non-operating | MIL-STD-202, method 213B, test condition F, 1500 gpk, 0.5 ms ½ sine pulse.<br>Three pulses in each direction of each axis, 18 pulses total. | Test | Appendix B |
| 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).<br>Outputs monitored. | Test | Appendix C |
| Thermal vacuum | MIL-STD-883, method 1001, condition G, three cycles with a base plate temperature of –55 °C to 85 °C.<br>Outputs monitored during TVAC cycles, record at temperatures noted under electrical. | Test, Increased temperature in lieu of vacuum | Appendix D<br>Certification TVAC Testing pending |
| Temperature cycling | 10 cycles from base plate temperature, MIL-STD-883, method 1010.9, condition C | Test | Appendix D |
| EMI | CE101, CE102, CS101, RE101, RE102, RS101, RS102 per MIL-STD-461 with setup per MIL-STD-462. | Analysis & Test | Appendix E<br>Certification EMI Testing pending |
| External<br>Visual inspection | No damage | Inspection | Appendix A |
| Steady state life test | 1000 hrs at Tc = 105 °C, 50% of rated load | Analysis, Extended Screening Test Heritage | Validation Test Pending |
| End-point electricals | Read and record ( –55 °C, 25 °C, 85 °C) | Test | Appendix D |

# 16. ATP Screening Test – (-HS) Hardened Standard

| Requirement | Test Method/Condition |
|---|---|
| External Visual | O&M – dimensions and mass |
| Initial Electrical | Full perfomance 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 perfomance at +25°C |
| Temperature Cycle | MIL-STD-883, Method 1010, Condition A, 1 cycle, +85°C to -55°C, operating<br>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 |

## 17. ATP Screening Test – (-HE) Hardened Extended (Consult factory)

| **Requirement** | **Test Method/Condition** |
|---|---|
| External Visual | O&M – dimensions and mass |
| Initial Electrical | Full perfomance at +25°C |
| Vibration | Workmanship operating vibration. MIL-STD-202, Method 214, 6 grms (50Hz-2kHz) 1-minute perpendicular to the board |
| Post Vibration Electrical | Full perfomance at +25°C |
| Temperature Cycle | MIL-STD-883, Method 1010, Condition A, 10 cycle, +85°C to -55°C, operating Outputs monitored during thermal cycles |
| Burn-in | 160 Hrs @ 105°C, 50% of rated load (outputs monitored) |
| Final Electrical | Full performance at -55°C, +25°C, and +85°C (deliverable data) |
| External Visual | No damage |

# 18. ATP Screening Test (-P) Prototypes

| Requirement | Test Method/Condition |
|---|---|
| External Visual | O&M – dimensions and mass |
| Electrical | Full performance at +85°C, +25°C. -55°C for initial first article of SA50 |
|  | Full performance at +25°C for previously qualified variation of SA50 |
| Vibration | None |
| Temperature Cycle | None |
| Burn-in | None |
| External Visual | No damage |

## 19. Ordering Information

The following chart defines the part number nomenclature of the **SA50-120** Single Series device.

Example part number: **SA50-120-5S-C-HS**

| | | | | |
|---|---|---|---|---|
| **Model** | SA50-120 | Standard Applications 50W, 120V input modules. (Other models and input voltages available) | | |
| **Main** | -3R3S | 3.3V | Main output voltage | |
| | -5S | 5V | | |
| | -12S | 12V | | |
| | -15S | 15V | | |
| | -28S | 28V | | |
| **Mechanical Package** | -A | Side, | 0.125in through | Mechanical packaging options. Electrical connections are either through the Top or the Side. And mounting holes are drilled through or tapped. |
| | -B | Top | 4-40 thread | |
| | -C | Side | M3 thread | |
| | -D | Top | 0.125in through | |
| | -E | Side | 4-40 thread | |
| | -F | Top | M3 thread | |
| **Radiation Hardness** | -HS | Hardened<br>Standard | We offer units with radiation hardened components in either standard screening or Extended screening. We also offer lower cost Prototype units meant for system design verification that are not radiation hardened. | |
| | -HE | Hardened Extended | | |
| | -P | Prototype | | |

NOTE: Microchip currently offers four models: SA50-120 Single, SA50-120 Triple, SA50-28 Single and SA50-28 Triple. We also offer customization design services, for changes in input volage, output voltages, or screening, Please contact us for more information.

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

# 20. Contact Information

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