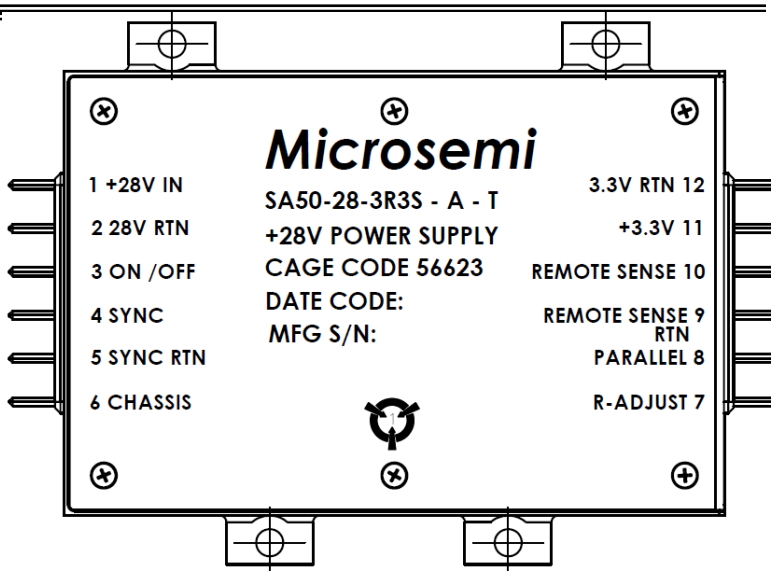
RADIATION HARDENED ISOLATED DC/DC CONVERTERS

SA50-28-3R3S
50 Watts Total Power
28 V_{dc} Input—3.3 V_{dc} Output



DESCRIPTION

The SA series of DC-DC converters are designed for the rigors of space, characterized for Total Ionizing Dose and Single Event Effects. Operating at a fixed frequency of 220 kHz, the SA family of parts can be externally synced with other frequency sources.

Microsemi Power Management Group (PMG) has achieved decades of flawless execution in harsh space environments. PMG's heritage, producing complex custom (radiation hardened) switching power designs and systems is now complimented with the introduction of the "SA Series" Standard Radiation Hardened DC/DC converter modules. The same rigorous design methodology employed for custom designs has been applied to the SA Family of standard products. Designed, manufactured and shipping in the USA, these space grade inverters are ideal choices for decades to come.

FEATURES

- **+28 V_{dc} Standard Military Power Interface**
- **100kRad (Si) TID; Single Event Effect rated**
- **Surface Mount Construction (non-hybrid)**
- **50W total power, high efficiencies 83%+**
- **Patented Magnetic Feedback**
- **Isolated Synchronization Input**
- **Adjustable Output via trim pin**
- **Primary referenced ON – OFF command**
- **Over-current Protection**
- **Input Under-voltage lockout**
- **MIL-STD-1547B design de-rating criteria**
- **100% Space level Environmental Screening**
- **Standard Mounting 2.05" x 3.05" x 0.475"**
- **Single & Triple Output Options**
- **SEE > 80 MeV•cm2 /mg Version Available**

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ELECTRICAL PARAMETERS

Absolute Maximum Ratings	
VIN range	-0.5Vdc to +60Vdc
Output power	50 Watts
Lead temperature	+300°C for 10 Sec.
Operating temperature	-55°C to +125°C
Storage temperature	-55°C to +125°C
Shock	1500 gpk, 0.5 msec, ½ sine
Constant Acceleration	50 g
Random Vibration	24.06 grms , 50-2000 Hz

Recommended Operating Conditions	
VIN range	+17Vdc to +50Vdc
Output power	2 watts to Max. Rated
Operating temperature [c]	-55°C to +125°C
Operating temperature [a,b]	-55°C to +70°C

a Meets derating per MIL-STD-975M

b Meets derating per MIL-STD-1547B

c For operation at +125°C see table Note 15

d Single Event Effect compliant

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ELECTRICAL PARAMETERS

Parameter	Group A Subgroup 1 25°C 2 -55°C 3 85°C	Conditions -55°C ≤ TCASE ≤ +85°C VIN = 28V DC ± 5%, CL = 0 unless otherwise specified	Limits Min	Nom	Max	Unit
Input Voltage	1,2,3	Note 2	17	28	50	V
Output Voltage (VOUT)						
	1	IOUT = 100% rated load, Note 5	3.28	3.30	3.32	V
	2,3	IOUT = 100% rated load, Note 5	3.25	3.30	3.35	V
Output Voltage Adjust (Vadj)						
	1,2,3	VIN = 60, 100, 125 Volts % relative to nominal output voltage	±10			%
Output Power (POUT)	1,2,3	VIN = 17, 28, 50 Volts, Notes 2,4	5		50	W
Output current (IOUT)						
	1,2,3	VIN = 17, 28, 50 Volts, Notes 2,3,4,5	1		15	A
Line regulation (VRLINE)						
	1,2,3	VIN = 17, 28, 50 Volts IOUT =10%, 50%, 100% rated, Notes 5, 14	-10		10	mV
Load regulation (VRLOAD)						
	1,2,3	VIN = 17, 28, 50 Volts IOUT =10%, 50%, 100% rated, Note 5, 13	-50		50	mV
Input current (IIN)	1,2,3	IOUT = 0, Pin 3 open		100	150	mA
		Pin 3 shorted to pin 2		2.0	5.0	
Output ripple (VRIP)						
	1,2,3	VIN = 17, 28, 50 Volts IOUT = 100% rated load, Notes 5, 6		25	50	mV p-p
Switching frequency (FS)	1,2,3	Sync. Input (Pin 4) open	200	220	240	kHz
Efficiency (EFF)	1,2,3	IOUT = 100% rated load, Note 5	79	80		%
Inhibit Input						
ON voltage (or Open Collector)		Note 1	4.5			V
OFF drive current (sink)			1000			µA
OFF voltage					2	V

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ELECTRICAL PARAMETERS

Parameter	Group A Subgroup 1 25°C 2 -55°C 3 85°C	Conditions -55°C ≤ TCASE ≤ +85°C VIN = 28V DC ± 5%, CL = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Synchronization Input						
frequency range		Ext. Clock on Sync. Input (Pin 4) Note 1	250		300	kHz
pulse high level			4.0		10.0	V
pulse low level			-0.5		0.5	V
pulse transition rate			200			V/µs
pulse duty cycle			10		80	%
Current Limit Point Expressed as a % of full rated output current	1,2,3	VOUT = 90% of Nominal, Note 5	105		135	%
Power dissipation, load fault (PD)	1,2,3	Short Circuit, Overload, Note 8			18	W
Output response to step load changes (VTLD)	4,5,6	Half Load to/from Full Load, Notes 5,9	-300		300	mV pk
Recovery time, step load changes (TTLD)	4,5,6	Half Load to/from Full Load, Note 5,9,10		50	200	µSec
Output response to step line changes (VTLN)		17V to/from 50V IOUT = 100% rated load, Notes 1, 5,11	-300		300	mV pk
Recovery time, step line changes (TTLN)		17V to/from 50V IOUT = 100% rated load, Notes 1, 5,11		50	200	µs
Turn-on Response						
Overshoot (VOS) (main)	4,5,6	No Load, Full Load Notes 5,12			500	mV
Turn-on Delay (TDLY)			1.0		5.0	mSec
Capacitive Load (CL)						
		IOUT = 100% rated load, No effect on DC performance, Notes 1, 5, 7			1000	µF
Line Rejection		DC to 50KHz, Notes 1, 5 IOUT = 100% rated load	40	60		dB
Isolation	1	Input (Pins 1,2,3) to Outputs Any Pin to Case (except pin 6) Sync and Sync Rtn to any pin and case	100			MΩ
Device Weight					110	g
MTBF		MIL-HDBK-217F2, SF, 35°C		8.22E+06		Hrs

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ELECTRICAL PARAMETERS

Radiation Tests				
Test	Conditions	Min	Typ	Unit
Total Ionizing Dose (Gamma)	MIL-STD-883, Method 1019 Operating bias applied during exposure,	100	300	KRad (Si)
Dose Rate (Gamma Dot) Temporary Saturation Survival	MIL-STD-883, Method 1023 Operating bias applied during exposure, Full Rated Load, VIN = 28V	1E8 4E10	1E11	Rad (Si) /sec
Neutron Fluence	MIL-STD-883, Method 1017	8E12	1E13	Neutrons /cm2
Single Event Effects SEU, SEL, SEGR, SEB	Heavy ions (LET) Operating bias applied during exposure,	35 [82]	39.7 [86]	MeV•cm2 /mg

Notes: Electrical Performance Characteristics

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. N/A
4. N/A
5. N/A
6. Guaranteed for a D.C. to 20MHz bandwidth. Tested using a 20kHz to 10MHz bandwidth.
7. Capacitive load may be any value from 0 to the maximum limit without compromising dc performance. A capacitive load in excess of the maximum limit may interfere with the proper operation of the converter's overload protection, causing erratic behavior during turn-on.
8. Overload power dissipation is defined as the device power dissipation with the load set such that VOUT = 90% of nominal.
9. Load step transition time ? 10 µs.
10. Recovery time is measured from the initiation of the transient to where VOUT has returned to within ±1% of its steady state value.
11. Line step transition time ? 100 µs.
12. 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.
13. Load Regulation relative to output voltage at 50% rated load.
14. Line Regulation relative to output voltage at 28Vdc input.
15. For operation at temperatures between +85°C and +125°C, derate power linearly from 50 watts to zero. Parameter limits are not guaranteed.

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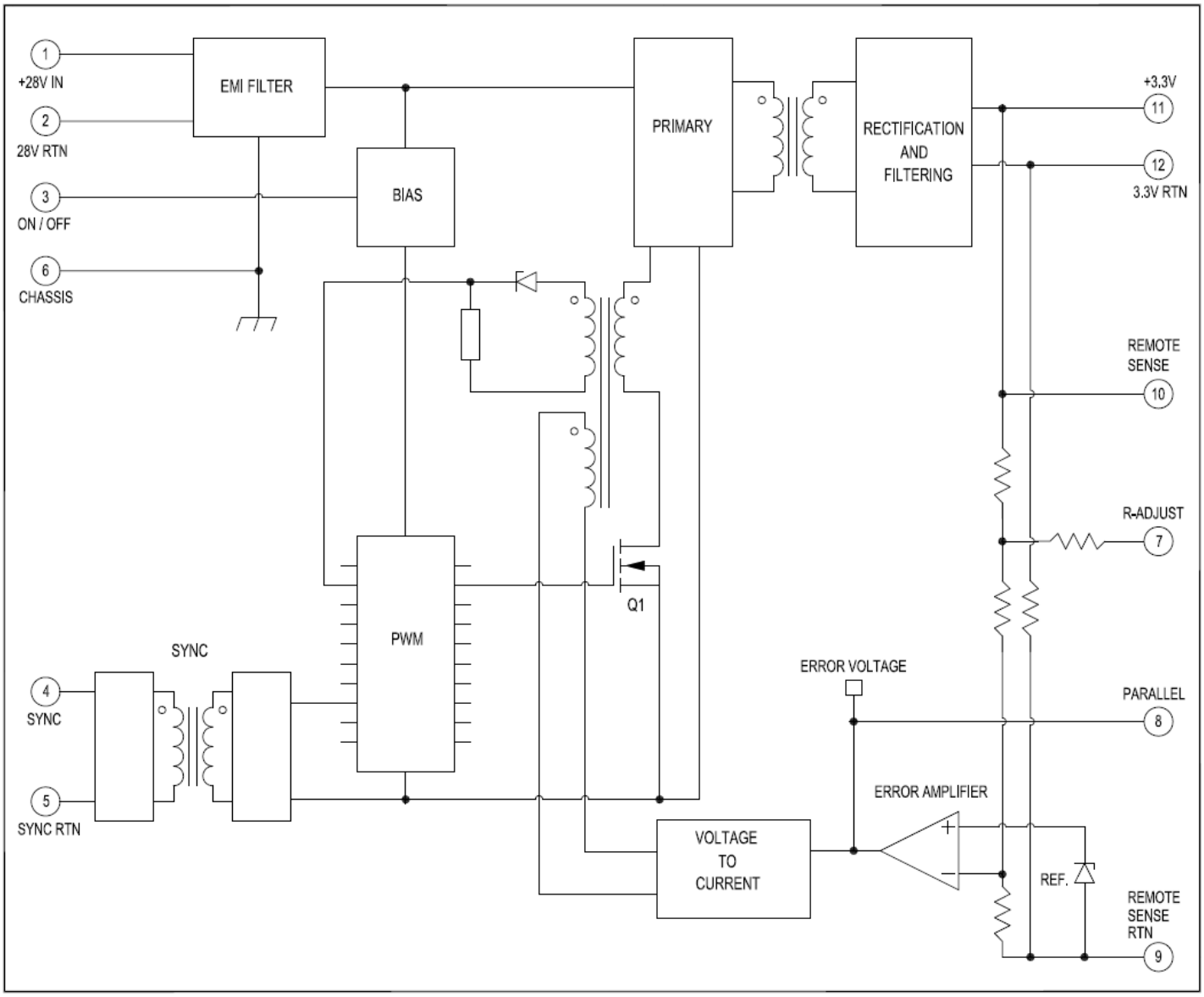
BLOCK DIAGRAM



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THEORY OF OPERATION

Internal controller bias is supplied during power up and in over-current scenarios via Darlington startup transistors off the input line. The controller power supply ramps up to the turn on point where it starts to supply drive to the main power converter MOSFET Q1. Under normal load conditions the output voltage will come up and a “Bootstrap” voltage is fed back to stabilize the Bias supply eliminating power loss in the start-up transistors.

Main power conversion occurs in the forward converter Q1 and associated Transformer. The secondary windings develop the required output voltages in parallel. A coupled inductor promotes good output cross regulation. Elimination of secondary side post regulators promotes high efficiency performance.

Output voltages are regulated on the main output secondary side. A TL1431 reference develops a current mode error signal which is chopped by the main forward transformer voltage and the summed with the primary side converter current in a patented magnetic feedback approach. The combined “V + I” error signal is applied to the primary controller’s ramp control input to complete the regulation loop.

The primary ON OFF command disables internal switch-mode action when pulled low.

The SYNC input is fully transformer isolated to allow operation from primary or secondary referenced sync drives.

The primary ON OFF command disables internal switch-mode action when pulled low.

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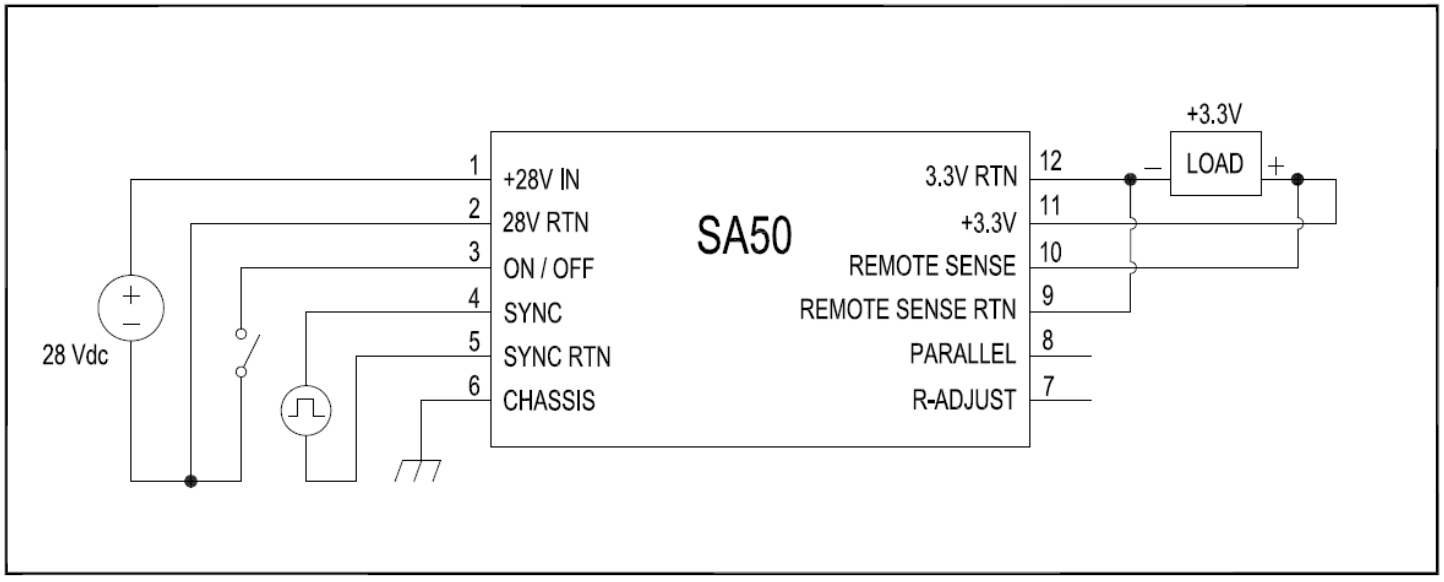
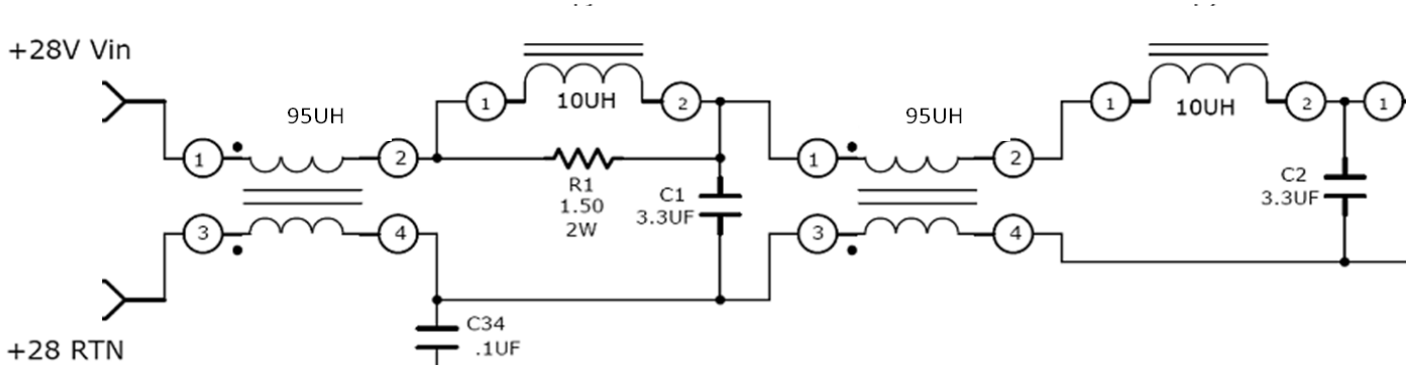
TYPICAL CONFIGURATION DIAGRAM



Short Circuit / Over Current Limit

The output current is limited by the built in current limit circuit, to protect the power supply and the load from overstress. The converter continues to regulate it's output voltage under this loading condition. If the load impedances of any of the outputs are further decreased, the converter turns off and attempts to restart after a delay.

EMI Filter



To achieve MIL-STD-461 EMI compliance an external filter should be added. Off the shelf filters such as Microsemi's SF200-28-28S are available. Alternatively an external discrete filter, such as the one shown above can be used.

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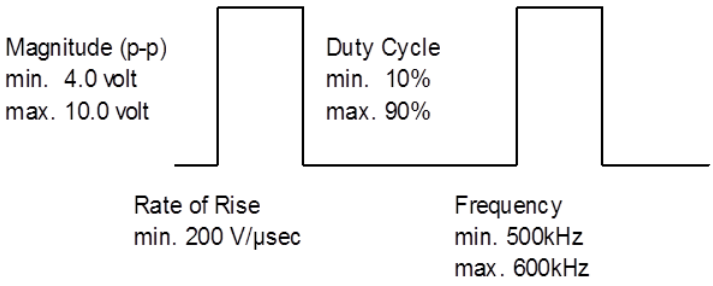
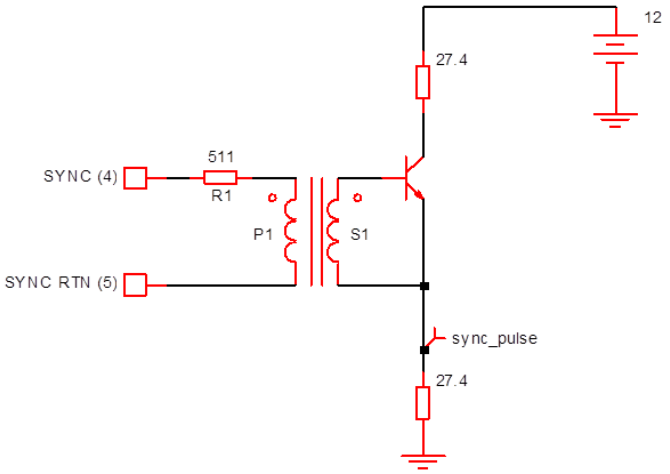
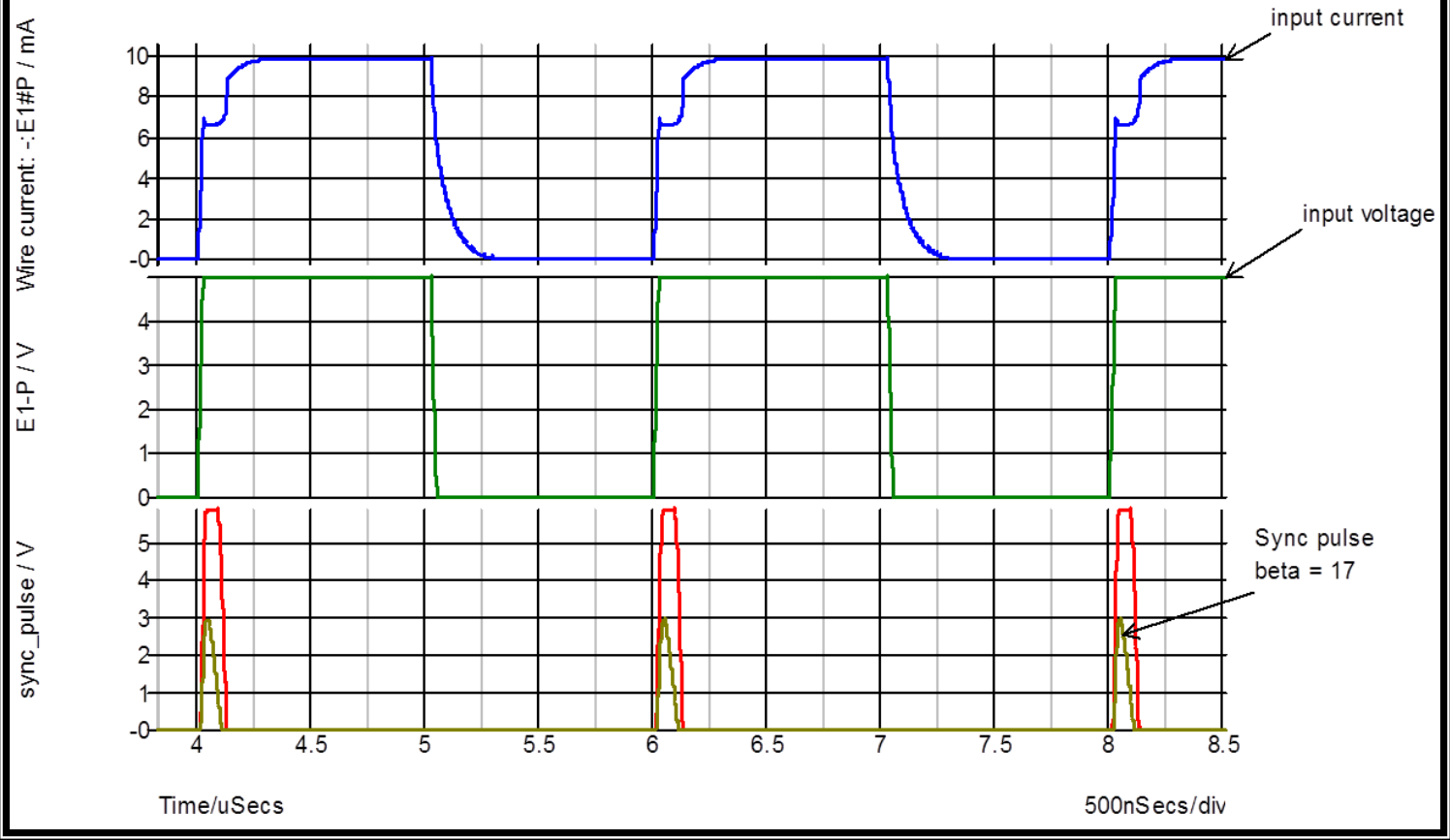
Sync Input:

The Power Supply's internal clock may be synchronized to an external signal. For enhanced system configuration flexibility and noise immunity, the sync input circuit is magnetically isolated from all other circuits and chassis. The interface is shown below. The circuit operates from the rising (leading) edge of the sync waveform, that generates a short synchronization pulse to the PWM controller. Note that the sync circuit DC input resistance is 500 Ohms. Specifically, the circuit driving the sync input needs to deliver a minimum of 5 mA of current into the input for a minimum of 50 ns, resulting in a minimum reflected voltage of 4 volts. Higher voltage drives are acceptable up to 10 volts, delivering approximately proportional higher current levels. Maintenance of high level voltage drive beyond 50 ns is not essential for correct synchronization function.





Typical Sync Operation



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APPLICATION DATA

Input Voltage Filtering

Place a low ESR ceramic capacitor and a Tantalum capacitor within one inch of the SA50 module's input terminals. The suggested minimum values are 4.7uF and 25uF respectively.

Under Voltage Operation

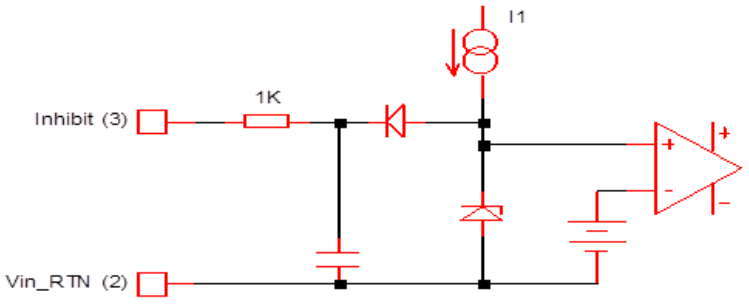
The Input Under-voltage protection feature prevents operation at an undesirably low input voltage.

The outputs are guaranteed to turn on at the specified minimum input voltage and guaranteed to be disabled below 70% of the specified minimum input voltage.

Inhibit Function

An external inhibit port is provided to control converter operation. The inhibit circuit is referenced to the DC Input return. The interface is as shown below.

The inhibit signal may be an open-collector or TTL type. Interface must sink 5 mA minimum to inhibit the output.



Inhibit Pin	Power Supply Output
Open	ON
> 4.5 volt	ON
Short	OFF
< 3.0 volt	OFF

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QUALIFICATION TESTS

Test 1/	Test Method/Condition	Custom Qualification Method	Reference
External Visual	Yes per O&M – dimensions and mass or std 883 2009	Inspection	Test Report
Electrical	Read & Record (-55 °C, +25 °C, +85 °C)	Test	Test Report
Shock, Non-Operating	MIL-STD-202, Method 213B, Test Condition F, 1500 gpk, 0.5 msec ½ sine pulse. Three pulses in each direction of each axis, 18 pulses total.	Similarity	QTR996 Appendix B
Vibration, Operating	MIL-STD-202, Method 214A, Cond. II-F, 24.06 grms random vibration, 50-2000 Hz, 3 minutes/axis, 9 min total. Outputs monitored.	Similarity	QTR996 Appendix C
Thermal Vacuum	MIL-STD-883, Meth 1001, Cond G, 3 cycles with base plate temperature of -55 °C to +85 °C. Outputs monitored during TVAC cycles, record at temperatures noted under	Similarity	QTR996 Appendix D*
Temperature Cycling	100 cycles from base plate temperature, MIL-STD-883, Method 1010.8, Cond A, -55 °C to +90 °C, 10-15 C°/min, 10 min dwell at temperature limits. Outputs monitored during	Similarity	QTR996 Appendix D
EMI Unit to be characterized to these requirements (Not	CE101,103,CS101,CS103,CS116,RE101,RE102, RS103, Radiated Susceptibility Magnetic Field 10 nT Magnetic Moment	Test	CE101, CE103, CS101, CS103 Only
External	No Damage	Similarity	QTR996
Visual Inspection		Similarity	QTR996
Electrical	Read & Record at +25 °C	Similarity	QTR996
Steady State Life test	1000 Hours@ Tc= +105 °C	Similarity	QTR996
End Point Electricals	Read & Record (-55 °C, +25 °C, +85 °C)	Similarity	QTR996

1/ Electrical test at +25°C shall be performed unless otherwise specified after each Environmental test

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RADIATION

Total Dose	100 krad, MIL-STD-883, Method 1019 Operating bias applied during exposure, Full Rated Load, VIN = 120 V	Similarity	RPT603
SEE (Analysis)	82 MeV•cm2 /mg , Heavy ions (LET) Operating bias applied during exposure, Full Rated Load, VIN = 120 V	Similarity	RPT603
ELDRS (Analysis)	40 krad, MIL-STD-883, Method 1019, Condition DD of MIL-STD-883 Method 1019.	Similarity	RPT603
Neutron Fluence (Analysis)	8E12 Min to 1E13 Typ. MIL-STD-883, Method 1017	Similarity	RPT603
Dose Rate (Gamma Dot) (Analysis) Temporary Saturation	MIL-STD-883, Method 1023 Operating bias applied during exposure, Full Rated Load, VIN = 120V	Similarity	RPT603

Analyses & Reports

1: Structural Analysis
2: Stress Analysis
3: Thermal Analysis
4: Radiation Analysis
5: Worse Case Analysis
6: Reliability Analysis
7: FEMA
8: First Article Qualification Test Report
9: EMI Test Report

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ATP TESTS

ATP Testing - Standard Screening

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 (50 Hz-2 kHz), 1 minute perpendicular to the board
Post Vibration Electrical	Functional verification at +25°C
Temperature Cycle	MIL-STD-883, Method 1010, Cond. A, 1 cycle, +85°C to -55°C, full performance.
Burn-in	40 Hrs @ 105°C, 50% of rated load
Final Electrical	Full performance at +25°C (deliverable data)
External Visual	No Damage

ATP Testing - Extended Screening

Requirement	Test Method /Condition
External Visual	Yes per O&M –dimensions and mass
Electrical	Read & Record at +25°C
Vibration Operating	Workmanship operating Vibration (outputs monitored) MIL-STD-202, Method 214 6 grms (50 Hz-2 kHz) 1 minute perpendicular to the board
Post Vibration Electrical	Read & Record at +25°C
Temperature Cycle	10 cycles from base plate temperature MIL-STD-883, M1010, Cond. A +85°C to -55°C outputs monitored during Thermal cycles
Burn-in	160 Hrs @ 105°C, 50% of rated load
Final Electrical	-55°C +25°C +85°C
External Visual	No Damage

Extended Screening: Microsemi PMG can perform additional tests as defined by customer requirements. Please contact the PMG sales contact shown on the last page of this datasheet for a quote on your specific needs.

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MECHANICAL INTERFACE

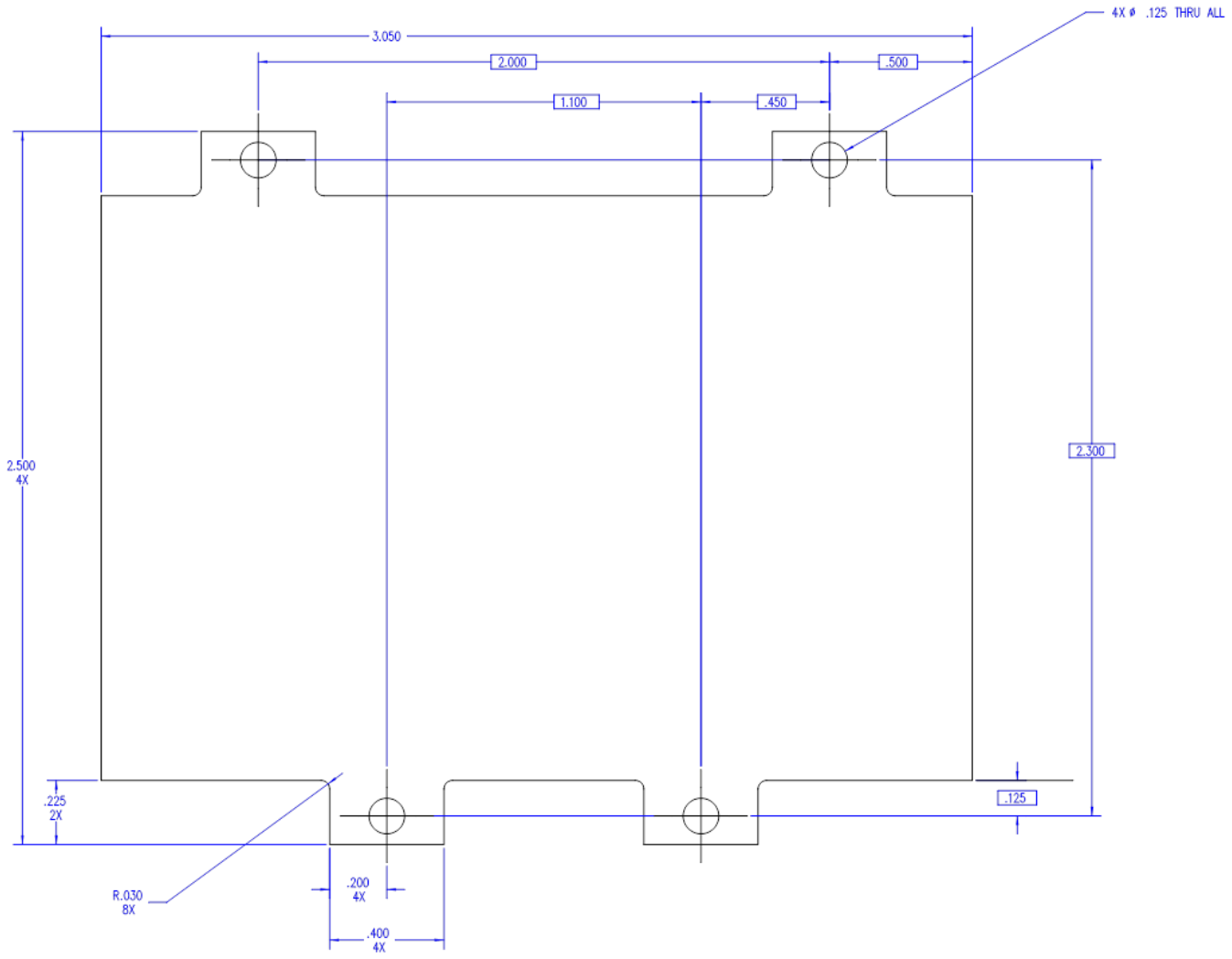

Figure 1

The surface on which an SA50 power supply is mounted is recommended to be flat to .005 in or less, with a surface roughness of 32 microinches or less. The mounting hole pattern and housing footprint for SA50 power supplies is shown in Figure 1.

The fasteners recommended for mounting of SA50 power supplies are 4-40 size fasteners, made from A-286 steel, used with NAS620C4 washers. Representative fasteners include NAS1101, NAS1352, or equivalent. The recommended torque is 6-8 in-lb.

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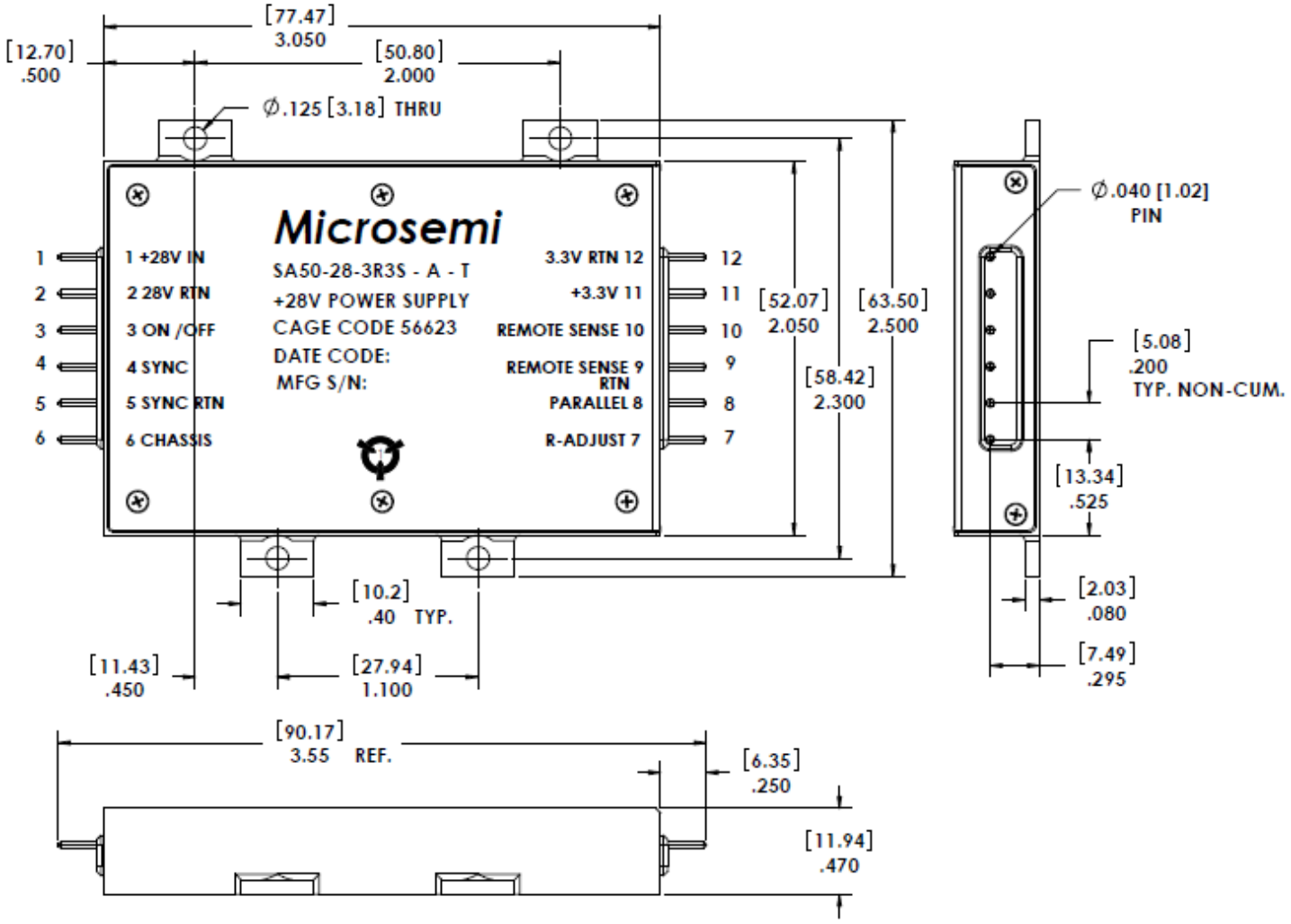
MECHANICAL DIAGRAM & PINOUT



PIN DESIGNATIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	+28V IN	7	R-ADJUST
2	28V RTN	8	PARALLEL
3	ON/OFF	9	REMOTE SENSE RTN
4	SYNC	10	REMOTE SENSE
5	SYNC RTN	11	+3.3V
6	CHASSIS	12	3.3V RTN

NOTES:

1.) PINS .040" (1.02 mm) DIAMETER.

2.) PINS MATERIAL: BRASS ALLOY 360, IAW ASTM B16.
PINS FINISH: ELECTRO-SOLDER .0005 MAX. THICK. (TIN LEAD) IAW SAE-AMS-P-81728.

3.) ALL DIMENSIONS IN INCHES (mm) TOLERANCES: .XX +/-.01 in. (.X +/-.254 mm)
.XXX +/-.005 in. (.XX +/-.127 mm).

4.) WEIGHT: 110 GRAMS MAX. (.24 LB MAX.)

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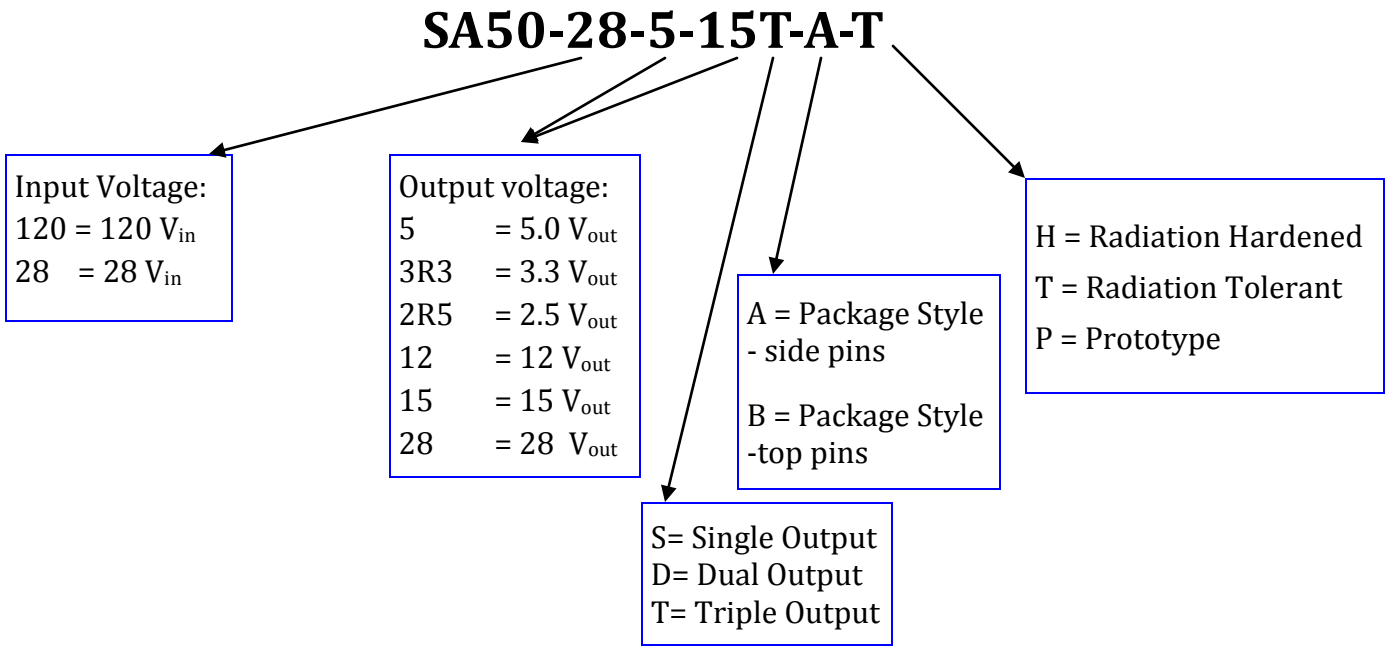
ORDERING INFORMATION



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