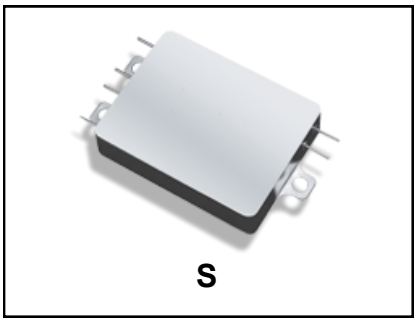
HYBRID-HIGH RELIABILITY RADIATION HARDENED LOW POWER DC-DC CONVERTER

28V Input, Single/Dual Output



S

Description

The S-Series of DC-DC converters are low power radiation hardened, high reliability devices designed for hostile radiation environments such as those encountered by geostationary earth orbit satellites, deep space probes and communication systems. Features include small size, high efficiency, low weight and a high tolerance to total ionizing dose, single event effects, and environmental stresses such as temperature extremes, mechanical shock, and vibration. Extensive documentation including Radiation Susceptibility, Thermal Analysis, Stress Analysis and MTBF are available.

The converters incorporate a fixed frequency single ended forward topology with magnetic feedback and an internal EMI filter utilizing large multilayer ceramic capacitors processed per MIL-PRF-49470 for improved reliability. All models include an external inhibit port . They are encased in a hermetic 1.71" x 1.31" x 0.45" steel package and weigh less than 50 grams. The package utilizes rugged ceramic feed-through copper core pins and is hermetically sealed using parallel seam welding.

Manufactured in a facility fully qualified to MIL-PRF-38534, these converters are fabricated utilizing DLA Land and Maritime qualified processes. For available screening options, refer to device screening table in the data sheet.

Non-flight versions of the S-Series converters are available for system development purposes. Variations in electrical specifications and screening to meet custom requirements can be accommodated. Consult IR HiRel San Jose for special requirements.

Features

- Total Dose > 100 kRads(Si)
- SEE Hardened to LET up to 82 MeV.cm^2/mg
- Low Weight < 50 grams
- Magnetically Coupled Feedback
- 18V to 40V Input Range
- Up to 10W Output Power
- Single and Dual Output Models Include 3.3, 5, 7, 12, 15, ±5, ±12, ±15V
- High Efficiency - to 82%
- -55°C to +125°C Operating Temperature Range
- 100MΩ @ 500VDC Isolation
- Under-Voltage Protection
- Short Circuit and Overload Protection
- External Inhibit
- Standard Microcircuit Drawings Available

Applications

- Geostationary or Low Earth Orbit Satellites
- Launch Vehicles
- Communication Systems

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Circuit Description

The S-Series converters utilize a single-ended forward topology with resonant reset. The nominal switching frequency is 525 kHz. Electrical isolation and tight output regulation are achieved through the use of a magnetically coupled feedback. Voltage feed-forward with duty factor limiting provides high line rejection.

Output power is limited under any load fault condition to approximately 135% for singles and 145% for duals of rated. An overload condition causes the converter output to behave like a constant current source with the output voltage dropping below nominal. The converter will resume normal operation when the load current is reduced below the current limit point. This protects the converter from both overload and short circuit conditions. There are no latching elements included in the load fault protection circuits to eliminate the possibility of falsely triggering the protection circuits during single event radiation exposure.

An under-voltage protection circuit prohibits the converter from operating when the line voltage is too low for safe operation. The converter will not start until the line voltage rises to approximately 12V.

An external enable port is provided to control converter operation. This input is intended for operation with an open collector transistor drive or a relay closure to the input return. The pin may be left open for normal operation and has a nominal open circuit voltage of 10.5V.

Design Methodology

The S-Series was developed using a proven conservative design methodology, which includes selecting radiation tolerant, and established reliability components and fully de-rating to the requirements of MIL-STD-975 and MIL-STD-1547 except for the CDR type of capacitors, a capacitor with 50V rating is used for in-circuit voltage stress of less than10V. Heavy de-rating of the radiation hardened power MOSFET virtually eliminates the possibility of SEGR and SEB. A magnetic feedback circuit is utilized instead of opto-couplers to minimize temperature, radiation and aging sensitivity. PSPICE was used extensively to predict and optimize circuit performance for both beginning and end-of-life. Thorough design analyses include Radiation Susceptibility (TREE), Worst Case, Stress, Thermal and Reliability (MTBF).

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Specifications

Absolute Maximum Ratings		**Recommended Operating Conditions**	
Input voltage range	-0.5V_{DC} to +60V_{DC}	Input voltage range	+16V_{DC} to +40V_{DC}
Output power	Internally limited	Output power	0 to Max. Rated
Lead temperature	+300°C for 10 seconds		
Operating temperature	-55°C to +135°C	Operating temperature	-55°C to +125°C
Storage temperature	-55°C to +135°C	Operating temperature[1]	-55°C to +70°C

[1] Meets de-rating per MIL-STD-975

Electrical Performance Characteristics

Parameter	**Group A Subgroup**	**Conditions** $-55°C \le T_C \le +85°C$, V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	**Limits**			**Unit**
			Min	**Nom**	**Max**	
Input voltage			18	28	40	V
Output voltage (V_{OUT})						
S2803R3S	1	I_{OUT} = 100% rated load, Note 4	3.27	3.30	3.33	V
S2805S	1		4.95	5.00	5.05	
S2807S	1		6.93	7.00	7.07	
S2812S	1		11.88	12.00	12.12	
S2815S	1		14.85	15.00	15.15	
S2805D	1		±4.95	±5.00	±5.05	
S2812D	1		±11.88	±12.00	±12.12	
S2815D	1		±14.85	±15.00	±15.15	
S2803R3S	2,3	I_{OUT} = 100% rated load, Note 4	3.230		3.370	
S2805S	2,3		4.900		5.100	
S2807S	2,3		6.895		7.105	
S2812S	2,3		11.760		12.240	
S2815S	2,3		14.700		15.300	
S2805D	2,3		±4.900		±5.100	
S2812D	2,3		±11.760		±12.240	
S2815D	2,3		±14.700		±15.300	
Output power (P_{OUT}) All models	1,2,3	V_{IN} = 18, 28, 40 Volts, Note 2	0		10	W
Output current (I_{OUT})						
S2803R3S	1,2,3	V_{IN} = 18, 28, 40 Volts, Note 2	0		3.03	A
S2805S			0		2.00	
S2807S			0		1.43	
S2812S			0		0.83	
S2815S			0		0.67	
S2805D		Either Output, Note 3	0.16		1.60	
S2812D		Either Output, Note 3	0.06		0.66	
S2815D		Either Output, Note 3	0.05		0.54	
Line regulation (VR_{LINE})	1,2,3	V_{IN} = 18, 28, 40 Volts				%
S28XXS		I_{OUT} = 0, 50%, 100% rated	-0.5		0.5	
S28XXD		I_{OUT} = 10%, 50%, 100% rated, Note 4	-0.5		0.5	
Load regulation (VR_{LOAD})	1,2,3	V_{IN} = 18, 28, 40 Volts				%
S28XXS		I_{OUT} = 0, 50%, 100% rated	-1.0		1.0	
S28XXD		I_{OUT} = 10%, 50%, 100% rated, Note 4	-1.0		1.0	

For Notes to Electrical Performance Characteristics, refer to page 6

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Electrical Performance Characteristics (continued)

Parameter	Group A Subgroup	Conditions $-55°C \le T_C \le +85°C$ V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Cross regulation (VR_{CROSS}) S2805D S2812D S2815D	1,2,3	Duals only, Note 5 V_{IN} = 18, 28, 40 Volts	 -5.0 -3.0 -3.0		 5.0 3.0 3.0	%
Total regulation S2803R3S S2805S S2807S S2812S S2815S S2805D S2812D S2815D	1,2,3	V_{IN} = 18, 28, 40 Volts Single Output: I_{OUT} = 0% ,50%,100% of rated current Note 14 Dual Output: I_{OUT} = 10% ,50%,100% of rated current Notes 4, 14	 -2.0 -2.0 -2.0 -2.0 -2.0 -5.0 -3.0 -3.0		 2.0 2.0 2.0 2.0 2.0 5.0 3.0 3.0	%
Input current (I_{IN}) S2803R3S S2805S S2807S S2812S S2815S S2805D S2812D S2815D	1,2,3	I_{OUT} = 0, Pin 4 open Pin 4 shorted to pin 2			 60 70 70 70 70 70 70 70 5.0	mA
Switching frequency (F_S)	1,2,3		475	525	575	kHz
Output ripple (V_{RIP}) S2803R3S S2805S S2807S S2812S S2815S S2805D S2812D S2815D	1,2,3	V_{IN} = 18, 28, 40 Volts I_{OUT} = 100% rated load Notes 4, 6			 50 50 45 50 60 80 80 80	mVp-p
Efficiency (E_{FF}) S2803R3S S2805S S2807S S2812S S2815S S2805D S2812D S2815D	1,2,3	I_{OUT} = 100% rated load Note 4	 68 75 76 78 77 76 76 76	 73 80 81 81 82 80 81 82		%
Enable input (Inhibit Function) Open circuit voltage Drive current (sink) Voltage range	1,2,3	Note 1	 9.5 -0.5		 11.5 500 50	 V µA V

For Notes to Electrical Performance Characteristics, refer to page 6

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Electrical Performance Characteristics (continued)

Parameter	Group A Subgroup	Conditions $-55°C \le T_C \le +85°C$ V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Current limit point Expressed as a percentage of full rated load current S2803R3S S2805S S2807S S2812S S2815S S2805D S2812D S2815D	1,2,3	V_{OUT} = 90% of Nominal, Note 4, 13	 105 105 110 105 110 105 105 105		 140 140 144 145 146 150 160 167	%
Power dissipation, load fault (P_D)	1,2,3	Short Circuit, Overload, Note 8			9.0	W
Output response to step load changes (V_{TLD})	4,5,6	Half Load to/ from Full Load, Notes 4,9	-300		300	mVpk
Recovery time, step load changes (T_{TLD})	4,5,6	Half Load to/from Full Load, Notes 4,9,10			200	µs
Output response to step line changes (V_{TLN})	4,5,6	18V to/from 40V I_{OUT} = 100% rated load, Notes 1,4,11	-300		300	mVpk
Recovery time, step line changes (T_{TLN})	4,5,6	18V to/from 40V I_{OUT} = 100% rated load, Notes 1,4,10,11			200	µs
Turn-on response Overshoot (V_{OS}) S2803R3S S2805S S2807S S2812S S2815S S2805D S2812D S2815D Turn-on delay (T_{DLY})	4,5,6	10% Load, Full Load Notes 4,12	 1.5		 500 600 750 1400 1650 600 1400 1500 10	mV ms
Capacitive load (C_L) S2803R3S S2805S S2807S S2812S S2815S S2805D S2812D S2815D	1	I_{OUT} = 100% rated load No effect on DC performance Notes 1, 4, 7 Each output on duals			2200 1000 750 180 120 500 90 60	µF

For Notes to Electrical Performance Characteristics, refer to page 6

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Electrical Performance Characteristics (continued)

Parameter	Group A Subgroup	Conditions $-55°C \le T_C \le +85°C$ V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Line rejection	1	I_{OUT} = 100% rated load DC to 50 kHz, Notes 1, 4		50		dB
Isolation	1	Input to Output or Any Pin to Case except pin 3, test @ 500VDC	100			MΩ
Device weight					50	g
MTBF		MIL-HDBK-217F2, SF, 35°C	1.5×10^6			Hours

Notes: Electrical Performance Characteristics Table

1. Parameter is tested as part of design characterization or after design changes. Thereafter, parameter shall be guaranteed to the limits specified.
2. Parameter verified during line and load regulation tests.
3. Output load current must be distributed such that at least 20% of the total load current is being provided by one of the outputs.
4. Load currents split equally between outputs on dual output models. For dual output models, the output may not meet regulation limits but the converter will not be damaged under this condition.
5. Cross regulation is measured with 20% rated load on output under test while changing the load on the other output from 20% to 80% of rated.
6. Guaranteed for a D.C. to 20 MHz bandwidth. Tested using a 20 kHz to 10 MHz 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 V_{OUT} = 90% of nominal.
9. Load step transition time ≥ 10 µs
10. Recovery time is measured from the initiation of the transient to where V_{OUT} 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 4) to the point where V_{OUT} = 90% of nominal.
13. Current limit point expressed as a percentage of full rated load current.
14. Total Regulation includes all combinations of line and load compared to the nominal output voltage. For dual models all line, load, and cross regulation conditions are tested per Note 4 and Note 5.

Radiation Performance Characteristics

Test	Conditions	Min	Typ	Unit
Total Ionizing Dose (Gamma)	MIL-STD-883, Method 1019.5 Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V	100		kRads(Si)
Single Event Effects SEU, SEL, SEGR, SEB	Heavy ions (LET) Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V **Test lab : Cyclotron Institute, Texas A & M University**	82		MeV•cm^2/mg

IR HiRel currently does not have does not have a DLA Land and Maritime certified Radiation Hardness Assurance Program.

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Figure 1. Block Diagram - Single Output

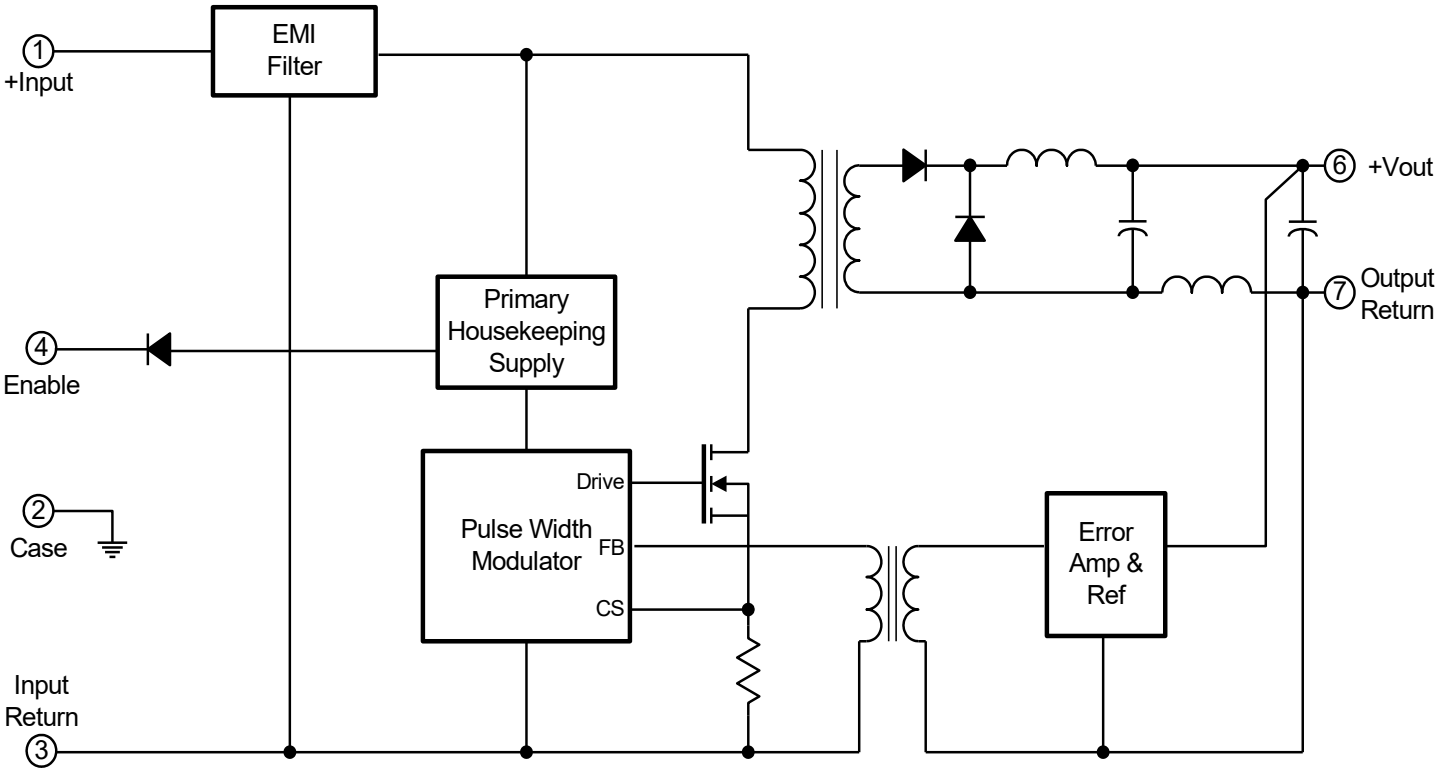
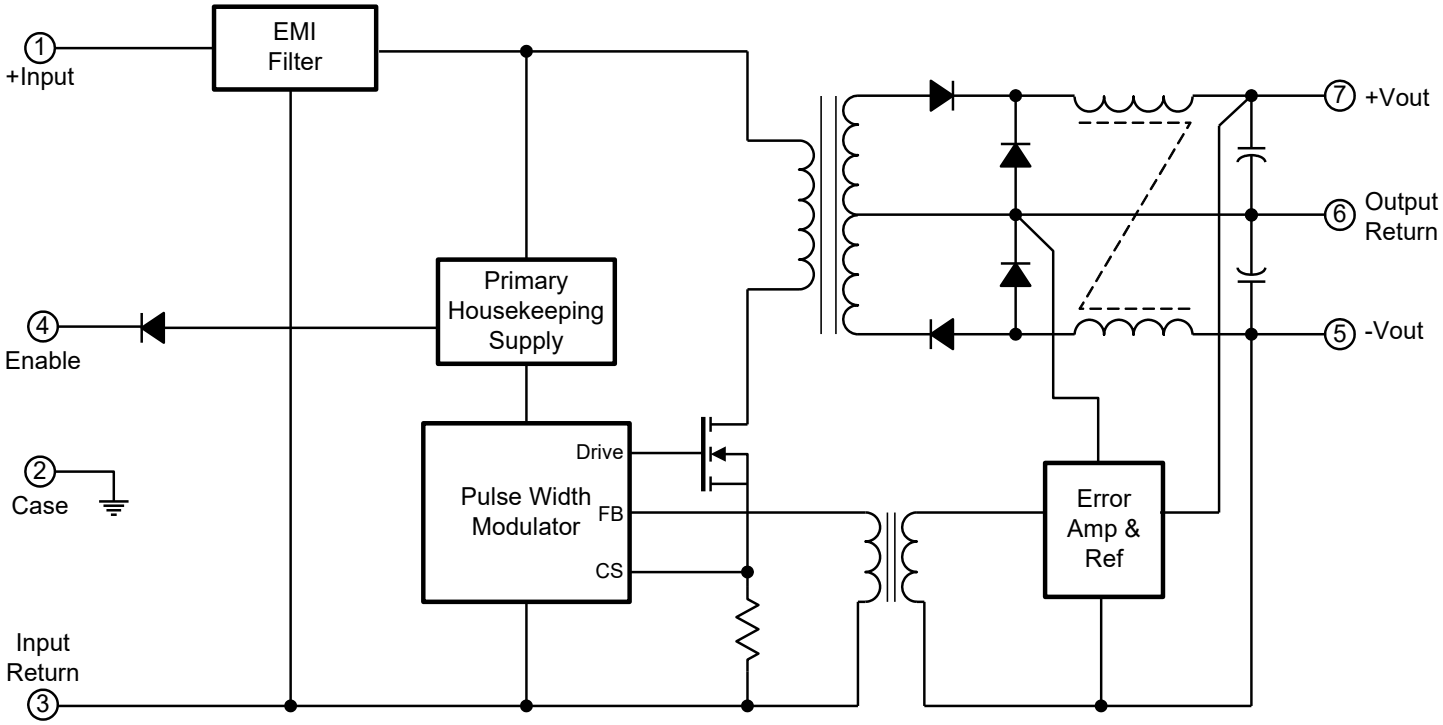
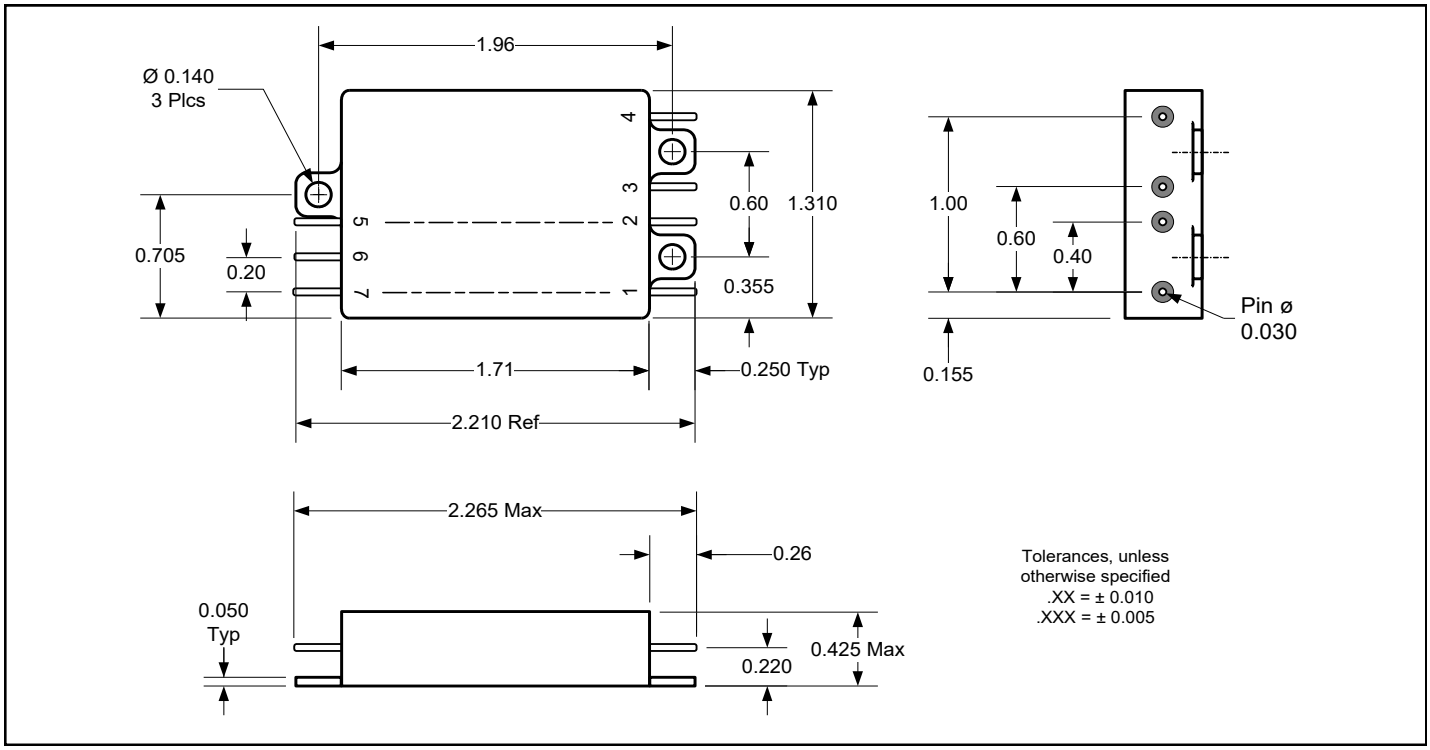


Figure 2. Block Diagram - Dual Output



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Mechanical Outline



Pin Designation

Pin #	Designation (Single)	Pin #	Designation (Dual)
1	+ Vin	1	+ Vin
2	Case	2	Case
3	Input Return	3	Input Return
4	Enable	4	Enable
5	NC	5	- Vout
6	+ Vout	6	Output Return
7	Output Return	7	+ Vout

Standard Microcircuit Drawing Equivalence Table

Standard Microcircuit Drawing Number	IR Standard Part Number
5962-04238	S2803R3S
5962-04239	S2805S
5962-13216	S2807S
5962-04240	S2812S
5962-04241	S2815S
5962-04242	S2805D
5962-04243	S2812D
5962-04244	S2815D

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Device Screening

Part Number Designator		/EM ①	/CK ②	5962-xxxxxxxKyy ③
Compliance Level	**MIL-PRF-38534**	—	**K level compliant**	**Class K SMD**
Certification Mark		—	**CK**	**QML**
Screening Requirement	**MIL-STD-883 Method**	—	—	—
Temperature Range	—	-55°C to +85°C	-55°C to +85°C	-55°C to +85°C
Element Evaluation	MIL-PRF-38534	N/A	Class K	Class K
Non-Destructive Bond Pull	2023	N/A	Yes	Yes
Internal Visual	2017	IR Defined	Yes	Yes
Temperature Cycle	1010	Cond C	Cond C	Cond C
Constant Acceleration	2001, Y1 Axis	3000 Gs	3000 Gs	3000 Gs
PIND	2020	N/A	Cond A	Cond A
Burn-In	1015	48 hrs @ 125°C	320 hrs @ 125°C (2 x 160 hrs)	320 hrs @ 125°C (2 x 160 hrs)
Final Electrical (Group A)	MIL-PRF-38534 & Specification	-55°C, +25°C	-55°C, +25°C, +85°C	-55°C, +25°C, +85°C
PDA	MIL-PRF-38534	N/A	2%	2%
Seal, Fine and Gross	1014	N/A	Cond CH	Cond CH
Radiographic	2012	N/A	Yes	Yes
External Visual	2009	IR Defined	Yes	Yes

Notes:

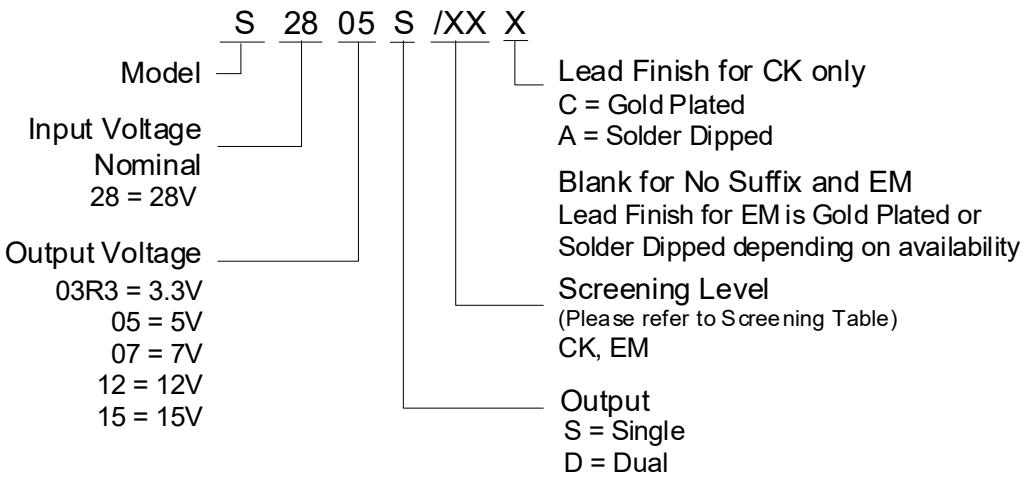
① **"EM" grade** shall only be form, fit and function equivalent to its Flight Model (FM) counterpart for electrical evaluation, and it may not meet the radiation performance. The EM Model shall not be expected to comply with MIL-PRF-38534 flight quality/workmanship standards, and configuration control. An EM build may use electrical equivalent commercial grade components

② **"CK" grade** is the flight model (FM) compliant to K Level screening as defined in the DLA Land and Maritime MIL-PRF-38534 requirements, but is not necessarily a DLA Land and Maritime qualified SMD per MIL-PRF-38534. The governing document for this part number designator is the IR HiRel datasheet (this document). Radiation rating as stated in the "Radiation Performance Characteristics" section, is verified by analysis and test per IR HiRel internal procedure. The part is marked with the IR base part number and the "CK" certification mark.

③ **"Class K SMD" grade** has a DLA qualified SMD per DLA MIL-PRF-38534 Class K which is the governing document for this part. The part is marked with the IR base part number, the SMD part number and the "QML" certification mark.

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Part Number Nomenclature



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