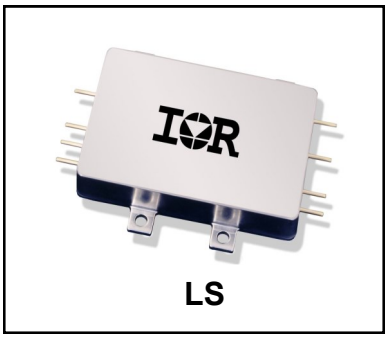
LS2806S

HYBRID-HIGH RELIABILITY RADIATION HARDENED DC-DC CONVERTER

28V Input, Single Output



LS

Description

The LS-Series of DC-DC converters are, high reliability devices designed for hostile radiation hardened environments. The LS-Series provide up to 30 watts output power, small size, low weight, integrated EMI filtering and a high tolerance to environmental stresses such as radiation, temperature extremes, mechanical shock, and vibration. Extensive documentation including, thermal analysis, stress analysis and reliability predictions are available.

The LS-Series of converters incorporate a fixed frequency single forward topology with magnetic feedback and an internal EMI filter. These converters are capable of meeting the conducted emissions requirements of MIL-STD-461C without any additional components. All models include an external inhibit port and have an adjustable output voltage. They are enclosed in a hermetic 1.5" x 2.3" x 0.425" steel package and weigh less than 80 grams. The package utilizes rugged ceramic feed-through copper core pins and is 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.

Variations in electrical specifications and screening to meet custom requirements can be accommodated.

Features

- 18 to 40V DC Input Range
- Total Ionization Dose > 100 kRad(Si)
- SEE Hardened to LET (Heavy Ions) up to 82 MeV•cm^2/mg (SEU, SEL, SEGB, SEGR)
- Internal EMI filter; Converter Capable of meeting MIL-STD-461C CE03
- Low Weight, < 80 grams
- Magnetically Coupled Feedback
- Up to 30W Output Power
- 6V Single Output
- High Efficiency - to 83%
- 100MΩ @ 500V_{DC} Isolation
- Under Voltage Protection
- Short Circuit and Overload Protection
- Adjustable Output Voltage
- External Inhibit
- > 4,000,000 Hour MTBF (SF)
- Standard Microcircuit Drawings Available

Applications

- Geo Synchronous Satellite
- Low Earth Orbit
- Deep Space Probe
- Communication and Display Systems
- Payload and Experiment LVPS

Circuit Description

The LS-Series converters utilize a single-ended forward topology with resonant reset. The nominal switching frequency is 500 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 and protection against output over voltage in the event of an internal control loop failure.

An internal EMI filter allows the converter to meet the conducted emissions requirements of MIL-STD-461C on the input power leads.

Output current is limited under any load fault condition to approximately 125% of rated. An overload condition causes the converter output voltage to drop 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. The current limit point exhibits a slightly negative temperature coefficient to reduce the possibility of thermal runaway.

An external inhibit port is provided to control converter operation. The converter's operation is inhibited when this pin is pulled low. It is intended to be driven by an open collector logic device. The pin may be left open for normal operation and has a nominal open circuit voltage of 11V with respect to the input return (pin 2).

The output voltage of all models can be adjusted using a single external resistor.

Design Methodology

The LS-Series was developed using a proven conservative design methodology derived from other space level designs that includes selection of established reliability components and fully de-rating to the requirements of MIL-STD-975 except for the CDR type of capacitors, a capacitor with 50V rating is used for in-circuit voltage stress of less than10V. A magnetic feedback circuit is utilized instead of opto-couplers to minimize temperature, aging and radiation sensitivity. PSPICE was used extensively to predict and optimize circuit performance for both beginning and end-of-life. Thorough design analyses include stress, thermal, and reliability (MTBF).

Specifications

Absolute Maximum Ratings		Recommended Operating Conditions	
Input Voltage range	-0.5V_{DC} to +60V_{DC}	Input Voltage range[1]	+18V_{DC} to +40V_{DC}
Output power	Internally limited	Output power	0 to Max. Rated
Lead Temperature	+300°C for 10 seconds	Operating case temperature	-55°C to +85°C
Operating Case temperature	-55°C to +125°C (Note 8)	Operating case temperature[2]	-55°C to +70°C
Storage temperature	-55°C to +135°C		

1. Meets MIL-STD-1547, MIL-STD-975 and NASA EEE-INST-002 up to the input voltage at 38.6V.
2. Meets de-rating per MIL-STD-975

Electrical Performance Characteristics

Parameter	Group A Subgroup	Conditions -55°C ≤ T_C ≤ +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})	1 2,3	I_{OUT} = 100% rated load I_{OUT} = 100% rated load, Note 5	5.94 5.88	6.0	6.06 6.12	V
Output power (P_{OUT})	1,2,3	V_{IN} = 18, 28, 40 Volts, Note 2	0		30	W
Output current (I_{OUT})	1,2,3	V_{IN} = 18, 28, 40 Volts, Note 2 Either Output,	0		5.0	A
Line regulation (VR_{LINE})	1,2,3	V_{IN} = 18, 28, 40 Volts I_{OUT} = 0, 50%, 100% rated	-0.5		0.5	%
Load regulation (VR_{LOAD})	1,2,3	V_{IN} = 18, 28, 40 Volts I_{OUT} = 0, 50%, 100% rated	-1.0		1.0	%
Input Current, no load (I_{IN})	1,2,3	I_{OUT} = 0, Pin 4 open			70	mA
Input current inhibited	1,2,3	Pin 4 shorted to pin 2			8.0	mA
Output Ripple, (V_{RIP})	1,2,3	V_{IN} = 18, 28, 40 Volts I_{OUT} = 100% rated load			50	mVp-p
Switching frequency (F_S)	1,2,3		425	500	575	kHz
Efficiency (E_{FF})	1,2,3	I_{OUT} = 100% rated load	78	82		%
Enable Input (Inhibit Function) open circuit voltage drive current (sink) voltage range		Note 1	9.5 -0.5		12 5.0 50	V mA V
Current Limit Point Expressed as a percentage of full rated load current	1,2,3	V_{OUT} = 90% of Nominal	105		145	%
Power dissipation, load fault (P_D)	1,2,3	Short Circuit, Overload, Note 3			14	W
Output response to step load changes (V_{TLD})	4,5,6	Half Load to/from Full Load, Note 6	-300		300	mVpk

For Notes to Electrical Performance Characteristics, refer to page 4.

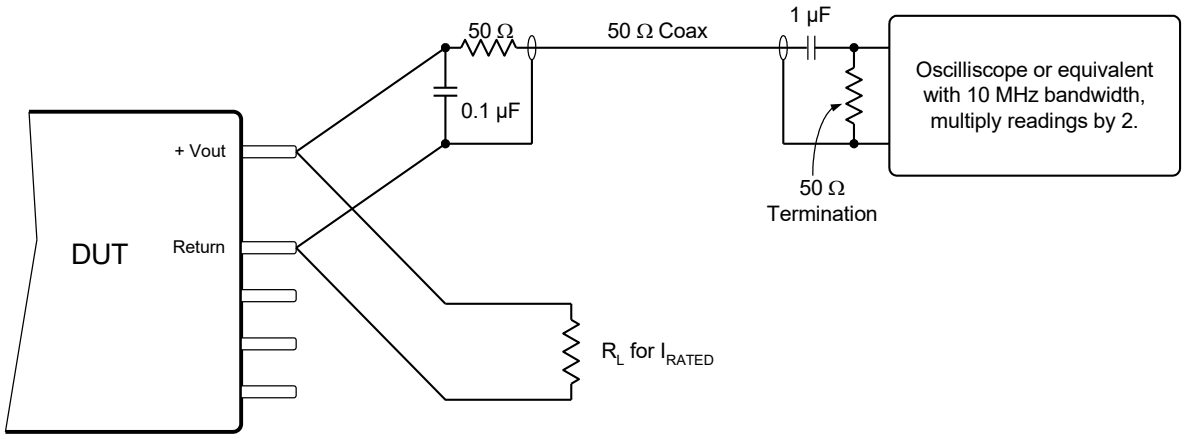
Electrical Performance Characteristics (continued)

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	
Recovery time, step load changes (T_{TLD})	4,5,6	Half Load to/from Full Load, Notes 4, 5			200	µs
Output response to step line changes (V_{TLN})		18V to/from 40V I_{OUT} = 100% rated load, Notes 1, 6	-300		300	mVpk
Recovery Time, step line changes (T_{TLN})		18V to/from 40V I_{OUT} = 100% rated load, Notes 1,5,6			200	µs
Turn-on Overshoot (V_{OS}) Turn-on Delay (T_{DLY})	4,5,6	10% Load, Full Load Note 7			600 10	mV ms
Capacitive Load (C_L)		I_{OUT} = 100% rated load No effect on DC performance			1000	µF
Line Rejection	1	I_{OUT} = 100% rated load DC to 50 kHz, Note 1	35	50		dB
Isolation	1	Input to Output or Any Pin to Case except Pin 3, test @ 500V_{DC}	100			MΩ
Device Weight					80	g
MTBF		MIL-HDBK-217F2, SF, 35°C	4.0 x10^6			Hr

Notes for 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. Overload power dissipation is defined as the device power dissipation with the load set such that V_{OUT} = 90% of nominal.
4. Load step transition time ≤ 10µs.
5. Recovery time is measured from the initiation of the transient to where V_{OUT} has returned to within ±1% of its steady state value.
6. Line step transition time ≤ 100µs.
7. 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.
8. For operation at temperatures between +85°C and 125°C, de-rate the maximum output power linearly from 100% to 75%.
9. End of Life (EOL) is ±3%

Fig. 1 - Circuit for measuring Output Ripple Voltage



Radiation Performance Characteristics

Test Inspection	Method	Min	Typ	Unit
Total Ionizing Dose (Gamma)	MIL-PRF-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

LS Series Output Voltage Adjustment

Output of LS series can be adjusted to be greater or less than the nominal output voltage with an external resistor. However, the ranges of the output voltages are limited depending on the model as specified in Table 1 and 2. An approximate value of the resistor can be determined using the following formula.

For Single Output Model:

$$Radj = \frac{A - (B * Vout)}{(C * Vout) - D}$$

Where:

R*adj* is the value of the external resistor in kilo-Ohms, Rdown or Rup in Figure 1 or 2. Power rating of the resistor tor shall be ≥ 0.125W. Metal film resistor with temperature coefficient of ≤ ±50 ppm and tolerance of ≤ 1% is recommended. However, the final selection is dependent on specific design requirements.

V*ovp* is the output voltage in volts.

A, B, C and D are unique constants depending on every model as shown in Table 1 for single output models.

Table 1: Single Output Voltage Ranges and Constants

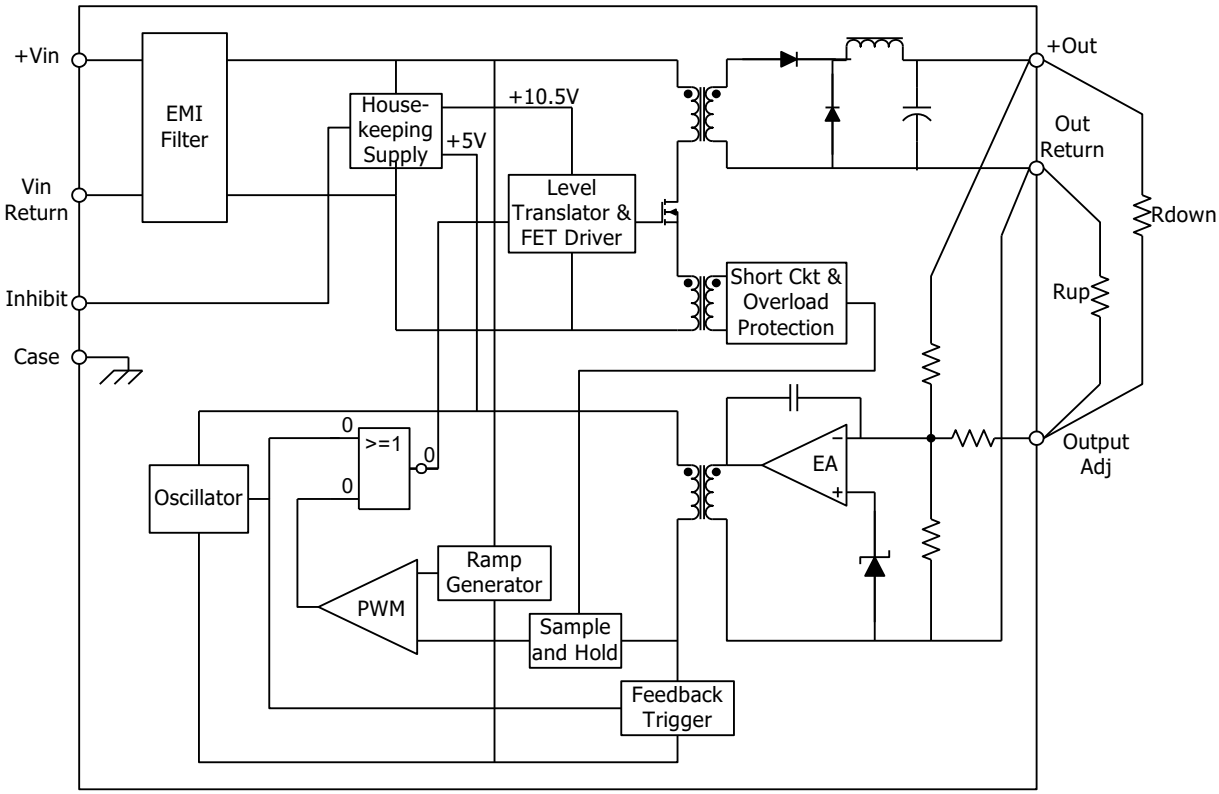
Model	Output Voltage Range (V) (1)	A	B	C	D
LS2806S	6.000 to 6.600	159.89	21.74	2.47	14.85
	5.400 to 6.000	130.52	37.21	37.21	12.12

Note:
(1). Also the minimum and maximum adjustment limits of the output voltage.

Placement of Radj

An external resistor must be added in order to trim the output voltage of an LS converter. The placement of an Radj resistor (Rdown or Rup) must be as shown in Figure 1 for single output models. Please note that the connections are made to the specific pins. Rup is placed across Out Return and Out Adj pins for output voltage greater than nominal output.

Figure 1: Radj Placement for Single Output Model



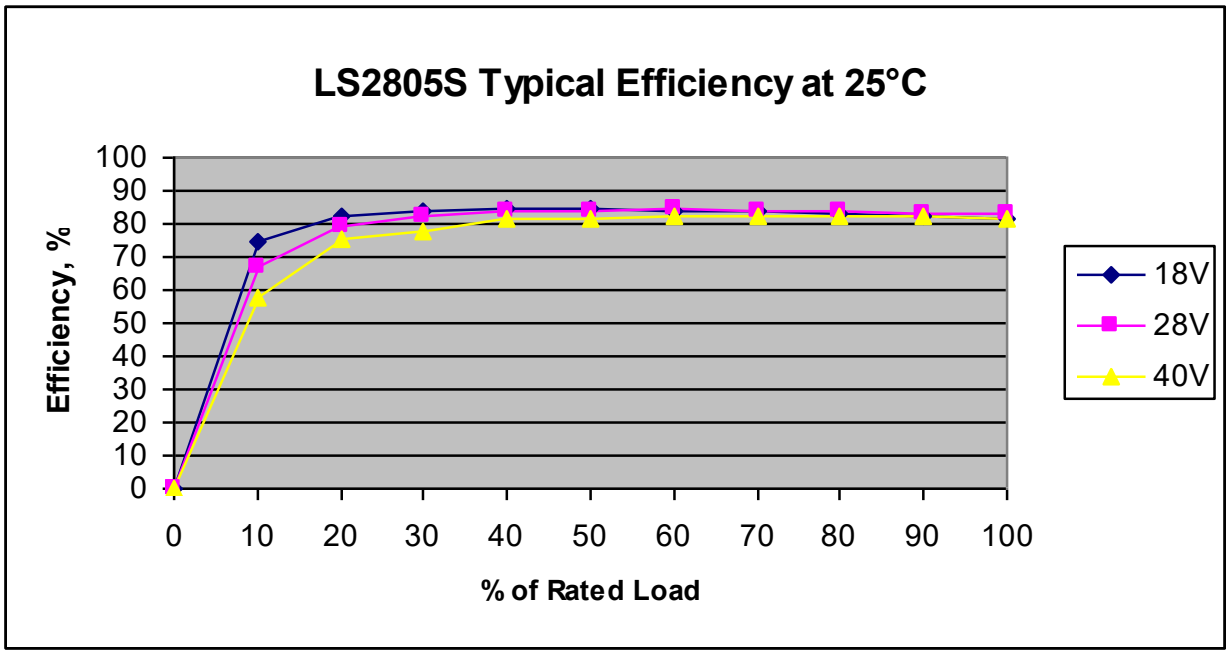
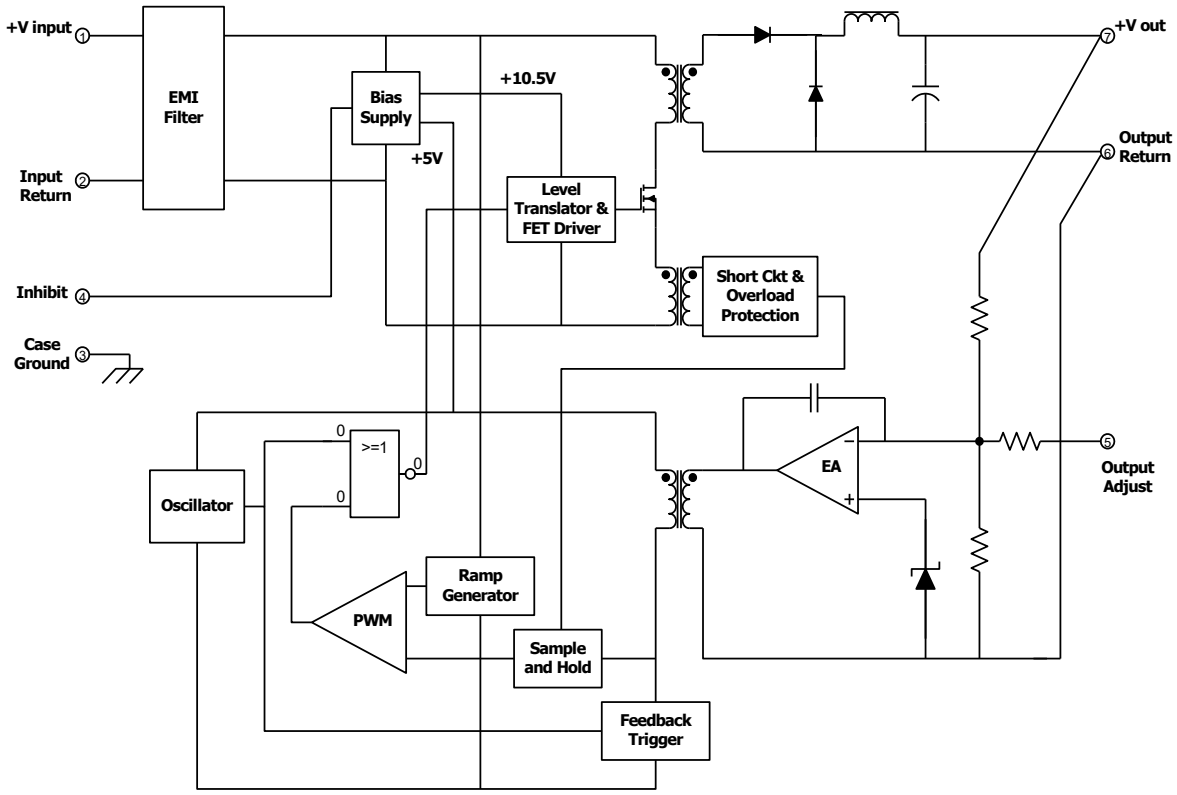


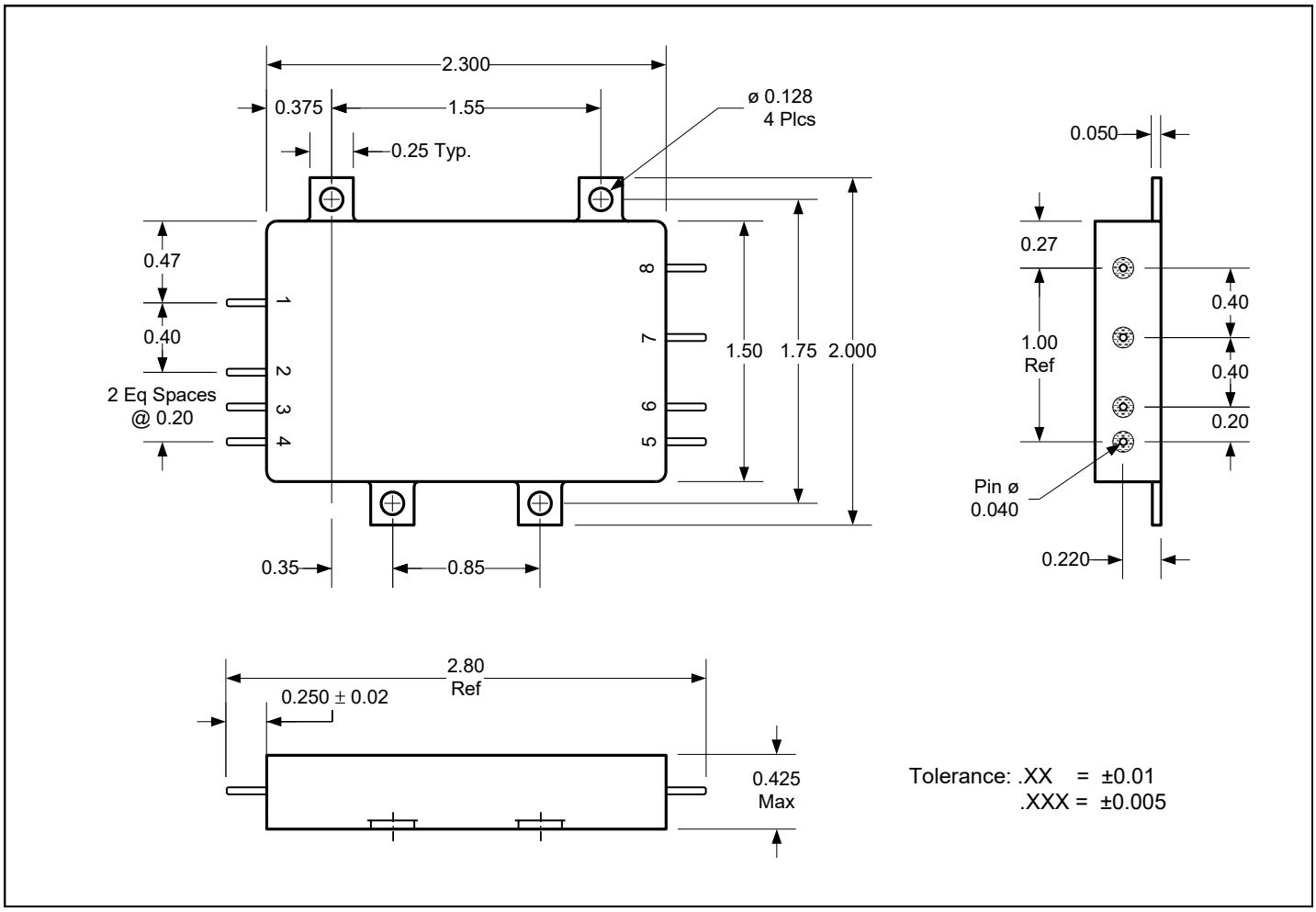
Figure 4: Block Diagram: Single Output Model



Pin Designation (Single)

Pin #	Single
1	+ Input
2	Input Return
3	Case Ground
4	Inhibit
5	Output Adjust
6	Output Return
7	+ Output
8	NC

Mechanical Outline



Device Screening

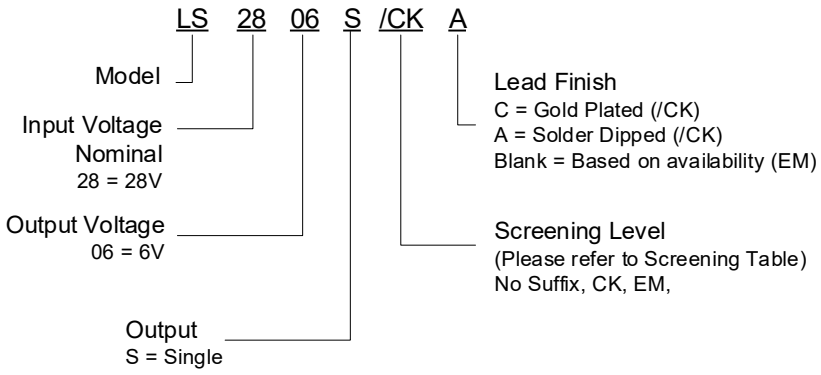
Part Number Designator		/EM ①	/CK ②
Compliance Level	**MIL-PRF-38534**	—	**K level compliant**
Certification Mark		—	**CK**
Screening Requirement	**MIL-STD-883 Method**	—	—
Temperature Range	—	Room Temperature	-55°C to +85°C
Element Evaluation	MIL-PRF-38534	N/A	Class K
Non-Destructive Bond Pull	2023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

Notes:

① **"EM" grade** parts are strictly intended to permit the customer to determine the electrical functionality of the device in the customer's application in ambient conditions. The use of EM devices in production applications presents an unquantifiable risk of failure and IR HiRel disclaims all responsibility for such failure.

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.

Part Numbering



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