

International **IOR** Rectifier

PD- 94693A

**LOW VOLTAGE
HIGH EFFICIENCY
RADIATION HARDENED
DC/DC CONVERTER**

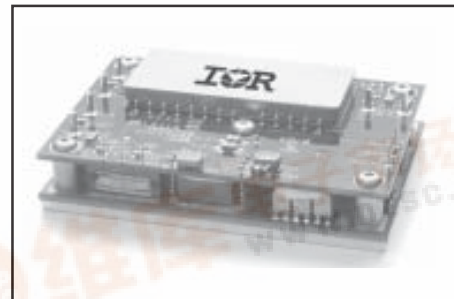
Z-SERIES

28V Input, Single Output

Description

The Z-Series of DC/DC converter modules has been specifically designed in response to the need for low voltage at moderate current levels supplied with the high efficiency and tight regulation dictated by modern digital processing applications. These converters are designed specifically for operation in radiation environments that are presented to commercial communication satellites operating in long term GEO and LEO orbits. They have been created to complement the spectrum of electrical and radiation performance available in the Advanced Analog ART2815T and M3G-Series converters. Requirements occurring in space vehicles operating in Geostationary orbits, launch boosters, scientific space probes and similar applications requiring a low voltage, high efficiency converter with well characterized radiation hardness performance will be optimally satisfied by the Z-Series converters.

An additional benefit of the Z-Series is high power density. This is facilitated by utilizing the best features of chip and wire hybrid technology and surface mount fabrication techniques. The hybrid portion is fabricated in a facility fully qualified to MIL-PRF-38534 and processed to class K requirements. The standard processing adopted for the Z-Series module has been created to assure with margin the reliability required for space applications. Applicable generic lot qualification test data including radiation performance will be made available on request. Variations to the standard screening may be accommodated. Consult IR Santa Clara for special requirements.



Features

- Output Voltages from 1.5 to 3.3 Volts
- 20 Amps Output Current
- Synchronous Rectification
- Efficiency up to 88%
- Nominal 28 Volt Input
- Total Ionizing Dose > 100KRad (Si)
- No SEE to LET > 80 MeV·cm²/mg
- -40°C to +85°C Operating Range
- Short Circuit Protection
- Remote Sensing
- Adjustable Output Voltage
- Flexible Mounting Configuration
- High Power Density
- Derating To MIL-STD-975, MIL-STD-1547, GSFC-PPL-21
- Fully Isolated - Input to Output and to Case
- Complimentary EMI Filter Available
- Base Plate Conduction Cooling

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Circuit Description

The Z-Series converters utilize a single ended forward topology with resonant reset. The nominal 250kHz switching frequency has been selected to optimize magnetic element size and switching loss. Electrical isolation between the primary and secondary sides of the converter is assured through exclusive use of magnetic coupling for all signals crossing the primary/secondary barrier. Voltage feed-forward is utilized to provide high line rejection.

To achieve the high efficiencies characterizing these converters, synchronous rectifiers have been used in place of rectifying diodes thus minimizing the conduction losses associated with those elements.

An internal EMI filter reduces the conducted emissions on the input power leads. A two-stage output filter reduces the typical output fundamental ripple to less than 20mV peak-to-peak.

Output current is limited under any load fault condition to approximately 125% 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. The current limit point exhibits a slightly negative temperature coefficient to reduce the possibility of thermal runaway.

An under-voltage lockout circuit prohibits the converter from operating when the line voltage is too low to maintain the output voltage. The converter will not start until the line voltage rises to approximately 16.5 volts and will shut down when the input voltage drops below 15.5 volts. This hysteresis voltage reduces the possibility of line noise interfering with the converter's start-up and shut down. An input overvoltage circuit is also in place that will shut down the converter if the input voltage exceeds approximately 60 V, thereby precluding the possibility of exceeding the voltage rating of the synchronous rectifiers.

An external inhibit port is provided to control converter operation. The nominal threshold relative to the input return (pin 2) is 1.4V. If 2.0 volts or greater are applied to the Inhibit pin (pin 3) then the converter will operate normally.

A voltage of 0.8V or less will cause the converter to shut-down. The pin may be left open for normal operation and has a nominal open circuit voltage of 4.0V.

A synchronization input is provided allowing operation of the converter synchronously with a user provided frequency source. This input permits synchronization of the converter to any compatible external frequency source operating in the band of 225 to 300 KHz and is edge triggered with synchronization initiated on the negative transition. This signal should be a negative going pulse referenced to the input return and have a 20% to 80% duty cycle. Compatibility requires the negative transition time to be less than 100 ns with minimum pulse amplitude of +4.25 volts referred to the input return. In the event of failure of an external synchronization source, the converter will revert to its own internally set frequency. When external synchronization is not desired, the sync input may be left open (unconnected) permitting the converter to operate at its' own internally set frequency.

Remote sense is provided to compensate for conduction losses in the connections between the converter outputs and the load. The use of this sense feature permits compensating for as much as 250 mV in both the output and return lines. (500 mV each leg, round trip)

An output adjust pin is provided permitting the user to adjust the output voltage by approximately $\pm 5\%$. Adjustment is accomplished by connecting a resistor between the adjust pin (Pin 10) and +Sense (Pin 9) or –Sense (Pin 11). The direction of the output change is opposite the sign of the sense pin to which it is connected, that is connecting to the – Sense pin causes an increase and connecting to the +sense pin causes a decrease in output voltage.

Design Methodology

The Z-Series was developed using a proven conservative design methodology that includes selecting radiation tolerant and established reliability components and fully derating to the requirements of GSFC PPL-21, MIL-STD-975 and MIL-STD-1547. Heavy derating 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 Worst Case, Stress, Thermal and Reliability (MTBF).

Absolute Maximum Ratings*

Input Voltage	-0.5V to +50VDC
Soldering	300°C, 10 Sec
Temperature Range	Operating – -40°C to +85°C Base Plate Storage – -55°C to +105°C Ambient

Recommended Operating Conditions

Input Voltage Range	+18V to +40V
Output Power	0 to Max rated
Base Plate Temperature	-40°C to +85°C

* Exceeding maximum rating limits may cause damage to the device

Electrical Characteristics -40°C ≤ T_{BASE} ≤ +85°C, V_{IN}=28 V_{DC} ±5%, C_L=0, unless otherwise specified.

Parameter	Group A Subgroups	Test Conditions	Min	Nom	Max	Unit
Input Voltage			18	28	40	V
Output Voltage		I _{out} = 0				
Z2801R5S	1		1.485	1.500	1.515	V
Z2802R5S	1		2.475	2.500	2.525	V
Z2803R3S	1		3.267	3.300	3.333	V
Z2801R5S	2, 3		1.470		1.530	V
Z2802R5S	2, 3		2.450		2.550	V
Z2803R3S	2, 3		3.234		3.366	V
Output Current ¹		V _{in} = 18, 28, 40 Volts				
Z2801R5S	1, 2, 3				20	A
Z2802R5S	1, 2, 3				20	A
Z2803R3S	1, 2, 3				15	A
Output Power ¹		100% load				
Z2801R5S					30	W
Z2802R5S					50	W
Z2803R3S					50	W
Output Ripple Voltage ²		V _{in} = 18, 28, 40 Volts BW = 20 Hz to 2 MHz				
Z2801R5S	1, 2, 3				20	mV _{PP}
Z2802R5S	1, 2, 3				30	mV _{PP}
Z2803R3S	1, 2, 3				40	mV _{PP}
Output Voltage Regulation ³		V _{in} = 18, 28, 40 Volts I _{out} = 10%, 50%, 100% load				
Line	1, 2, 3				±0.5	%
Load	1, 2, 3				±0.5	%
Output Voltage Temperature Coefficient					±0.02	%/°C

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International
IR Rectifier

Electrical Characteristics (Continued) $-40^{\circ}\text{C} \leq T_{\text{BASE}} \leq +85^{\circ}\text{C}$, $V_{\text{IN}}=28 \text{ V}_{\text{DC}} \pm 5\%$, $C_L=0$, unless otherwise specified.

Parameter	Group A Subgroups	Test Conditions	Min	Nom	Max	Unit
Input Current	No Load	1, 2, 3	I _{out} =0, Inhibit =open		500	mA
	Inhibited	1, 2, 3	Inhibit shorted to input return		5 14	mA
Input Ripple Current ²	1, 2, 3	V _{in} = 18, 28, 40 Volts, 100% load, BW = 20 Hz to 2 MHz			50	mA _{pp}
Efficiency	Z2801R5S	1	79	80		%
	Z2802R5S	1	83	85		%
	Z2803R3S	1	85	88		%
	Z2801R5S	2, 3	78			%
	Z2802R5S	2, 3	82			%
	Z2803R3S	2, 3	84			%
Isolation	1	Input to output or any pin to case (except case ground pin) at 500Vdc	100			MΩ
Capacitive Load	4	No effect on DC performance			2000	μF
Short Circuit Power Dissipation	1, 2, 3				19	w
Switching Frequency	4, 5, 6	100% load	225	250	275	KHz
Sync Frequency Range	4, 5, 6	100% load	225		300	KHz
Turn-on Characteristics	Delay	1, 2, 3			30	mS
	Overshoot	1, 2, 3			10	%
MTBF		MIL-HDBK-217F, N2 SF @ T _B = 35°C	3.96			Mhrs
Weight					200	g

Notes to Specifications

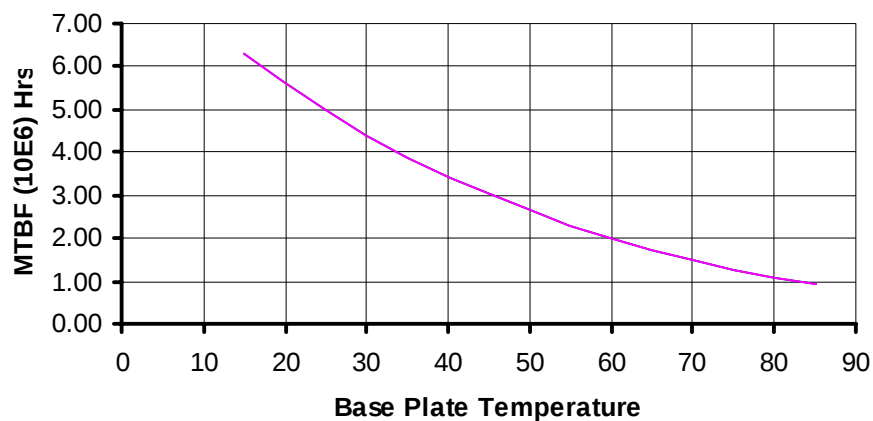
1. Some parameters are not directly measured but are verified as part of another test
2. Measurement guaranteed for a bandwidth of 20 MHz. Tested with a bandwidth of 20KHz to 2MHz.
3. Regulation measured for all combinations of line and load conditions shown. Worst limit is presented for each parameter.

Flight Screening for Z-Series

Test No.	Description	Conditions	Comments
1.	100% Full Functional Electrical Test (Group A)	25°C (Subgroup 1) only	
2.	100% Temperature Cycle, Operational	-40°C to +100°C, 5 Cycles	Record V_{in} , I_{in} and V_{out}
3.	100% Full Functional Electrical Test (Group A)	25°C (Subgroup 1) only	
4.	Sample Group A, Min, Max temperature	-40°C, +85°C (Subgroups 2, 3)	Sample 5(0)
5.	100% Burn-in	+85°C Baseplate, 96 Hours	
6.	100% Random Vibration, 3-Axis operational	MIL-STD-883, Method 2026, Cond 1G, 1 minute each axis	Record V_{in} , I_{in} and V_{out}
7.	100% Full Functional Electrical Test (Group A) 3 temperature	-40°C, +25°C, +85°C (Subgroups 1, 2, 3)	Read and record data

Typical MTBF for Z-Series

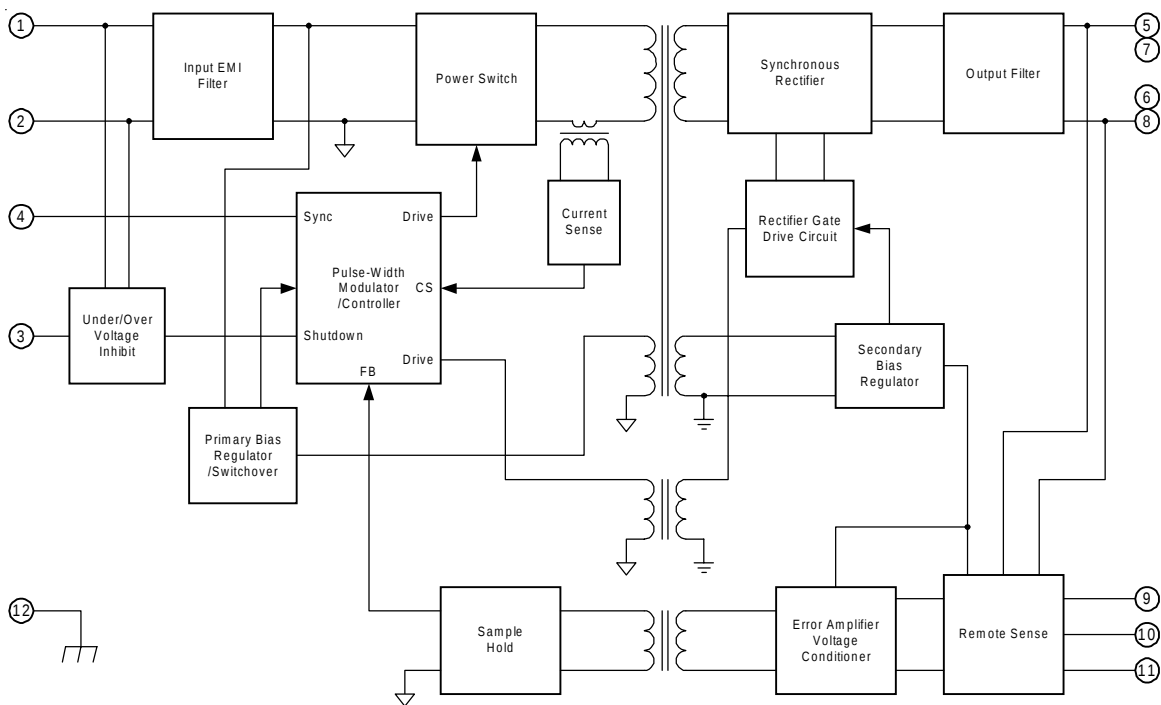
MTBF vs Temperature



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Functional Block Diagram

Single Output



Pin Designation

Pin No.	Designation	Pin No.	Designation
1	Input +	7	Output +
2	Input -	8	Output Return
3	Enable	9	Sense +
4	Sync. Input	10	Output Adjust
5	Output +	11	Sense -
6	Output Return	12	Chassis

Part Numbering

Z 28 01R5 S /EM

Model ———
Input Voltage
28 = 28V Nominal
Output Voltage
01R5 = 1.5V
02R5 = 2.5V
03R3 = 3.3V

Screening
/EM = Engineering Model
Blank = Flight Model

Outputs
S = Single

Mechanical Diagram

