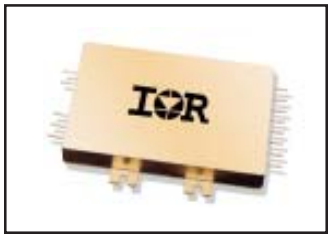
International
IOR Rectifier

PD - 94534D

G-SERIES

28V Input, Single/Dual Output

ADVANCED ANALOG HIGH RELIABILITY RADIATION HARDENED DC/DC CONVERTER



Description

The G-Series of DC/DC converters are radiation hardened, high reliability converters designed for extended operation in hostile environments. Their small size and low weight make them ideal for applications such as geostationary earth orbit satellites and deep space probes. They exhibit a high tolerance to total ionizing dose, single event effects and environmental stresses such as temperature extremes, mechanical shock, and vibration. All components are fully derated to meet the requirements of MIL-STD-975, MIL-STD-1547 and GSFC PPL-21 Appendix B. Extensive documentation including Radiation Susceptibility, Thermal, Stress, Worst Case, Failure Modes and Effects analyses and MTBF are available for customer review and included with each order.

The converters incorporate a fixed frequency single ended forward topology with magnetic feedback and an internal EMI filter that utilizes multilayer ceramic capacitors that are subjected to extensive lot screening for optimum reliability. These converters are capable of meeting the conducted emissions and conducted susceptibility requirements of MIL-STD-461C without any additional components. External inhibit and synchronization input and output allow these converters to be easily incorporated into larger power systems. They are enclosed in a hermetic 3" x 2" x 0.4" package constructed of an Aluminum/Silicon-Carbide (Al/SiC) base and an Alloy 48 ring frame and they weigh less than 90 grams. The package utilizes rugged ceramic feedthrough copper core pins and is sealed using parallel seam welding.

Full environmental screening includes temperature cycling, constant acceleration, fine and gross leak, particle impact noise detection (PIND), radiographic and 320 hours burn-in.

Non-flight versions of the G-Series converters are available for system development purposes. Variations in electrical specifications and screening to meet custom requirements can be accommodated.

Features

- Total Dose > 200K Rad(Si), typically usable to > 300K Rad(Si)
- SEE 82 MeV•cm²/mg
- Internal EMI filter; Converter Capable of meeting MIL-STD-461C CE03 and CS01
- Low Weight, < 90 grams
- Magnetically Coupled Feedback
- 18V to 50V DC Input Range
- Up to 40W Output Power
- Single and Dual Output Models Include 3.3, 5, 12, 15, ±5, ±12 and ±15V
- High Efficiency - to 82%
- -55°C to +125°C Operating Temperature Range
- 100MΩ @ 500VDC Isolation
- Under-Voltage Lockout
- Short Circuit and Overload Protection
- Output Over Voltage Limiter
- Remote Sense on Single Output Models
- Adjustable Output Voltage for Duals
- Synchronization Input and Output
- External Inhibit
- > 5,000,000 Hour MTBF

Applications

- Geostationary Earth Orbit Satellites (GEO)
- Deep Space Satellites / Probes
- Strategic Weapons and Communication Systems

Circuit Description

The G-Series converters utilize a single-ended forward topology with resonant reset. The nominal switching frequency is 500kHz. 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. This mechanism limits the maximum output voltage to approximately 20% over the nominal regardless of the line voltage.

An internal EMI filter allows the converter to meet the conducted emissions requirements of MIL-STD-461C on the input power leads. A two-stage output filter reduces the typical output 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. The one volt of hysteresis reduces the possibility of line noise interfering with the converter's start-up and shut down.

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.

Synchronization input and output allow multiple converters to operate at a common switching frequency. Converters can be synchronized to one another or to an externally provided clock. This can be used to eliminate beat frequency noise or to avoid creating noise at certain frequencies for sensitive systems.

Remote sense is provided on the single output models to compensate for voltage drops in the interconnects between the converter and the load. The output voltage of dual output models can be adjusted by a single external resistor.

Design Methodology

The G-Series was developed using a proven conservative design methodology which includes selecting radiation tolerant and established reliability components and fully derating to the requirements of MIL-STD-975 and MIL-STD-1547. Careful sizing of decoupling capacitors and current limiting resistors minimizes the possibility of photo-current burnout. 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 and RadSPICE were 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, Failure Modes and Effects (FMEA) and Reliability (MTBF).

Absolute Maximum Ratings

Input voltage range - -0.5Vdc to +80Vdc
Output power - Internally limited
Lead temperature - +300°C for 10 seconds
Operating temperature - -55°C to +135°C
Storage temperature - -55°C to +135°C

Recommended Operating Conditions

Input voltage range - 18Vdc to +60Vdc
Input voltage range[1] - 18Vdc to +50Vdc
Output power - 0 to Max. Rated
Operating temperature[2] - -55°C to +125°C
Operating temperature[1] - -55°C to +70°C

[1] Meets derating per MIL-STD-975
[2] For operation at +125°C see table note 13

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	50	V
Output Voltage (Vout)						
M3G2803R3S	1	I_{OUT} = 100% rated load	3.28	3.30	3.32	V
M3G2805S	1	Note 4	4.98	5.00	5.02	V
M3G2805R2S	1		5.17	5.20	5.23	V
M3G2812S	1		11.95	12.00	12.05	V
M3G2815S	1		14.94	15.00	15.06	V
M3G2805D	1		±4.98	±5.00	±5.02	V
M3G2812D	1		±11.95	±12.00	±12.05	V
M3G2815D	1		±14.94	±15.00	±15.06	V
M3G2803R3S	2,3	I_{OUT} = 100% rated load	3.24		3.36	V
M3G2805S	2,3	Note 4	4.93		5.07	V
M3G2805R2S	2,3		5.13		5.27	V
M3G2812S	2,3		11.84		12.16	V
M3G2815S	2,3		14.80		15.20	V
M3G2805D	2,3		±4.93		±5.07	V
M3G2812D	2,3		±11.84		±12.16	V
M3G2815D	2,3		±14.80		±15.20	V
Output power (P_{OUT})						
M3G2803R3S	1,2,3	V_{IN} = 18, 28, 50 Volts, Note 2	0		30	W
All Others			0		40	W
Output current (I_{OUT})						
M3G2803R3S	1,2,3	V_{IN} = 18, 28, 50 Volts, Note 2	0		9.1	A
M3G2805S			0		8	A
M3G2805R2S			0		7.7	A
M3G2812S			0		3.34	A
M3G2815S			0		2.67	A
M3G2805D		Either Output, Note 3	0		6.4	A
M3G2812D		Either Output, Note 3	0		2.67	A
M3G2815D		Either Output, Note 3	0		2.14	A
Line regulation (VR_{LINE})	1,2,3	V_{IN} = 18, 28, 50 Volts I_{OUT} = 0, 50%, 100% rated, Note 4	-10		10	mV
Load regulation (VR_{LOAD})	1,2,3	I_{OUT} = 0, 50%, 100% rated, Note 4 V_{IN} = 18, 28, 50 Volts	-0.5		0.5	%
Cross regulation (VR_{CROSS})						
M3G2805D	1,2,3	Duals only, Note 5	-5.0		5.0	%
M3G2812D		V_{IN} = 18, 28, 50 Volts	-3.0		3.0	%
M3G2815D			-3.0		3.0	%

For Notes to Specifications, refer to page 5

Electrical Performance Characteristics (continued)

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 current (I_{IN})	1,2,3	I_{OUT} = 0, Pin 3 open		40	80	mA
		Pin 3 shorted to pin 2		2	5	
Switching frequency (F_S)	1,2,3	Sync. Input (Pin 4) open	450	500	550	KHz
Output ripple (V_{RIP})						
M3G2803R3S	1,2,3	I_{OUT} = 100% rated load Notes 4, 6		15	35	mV p-p
M3G2805S				20	50	mV p-p
M3G2805R2S				25	50	mV p-p
M3G2812S				25	60	mV p-p
M3G2815S				25	80	mV p-p
M3G2805D				20	50	mV p-p
M3G2812D				30	60	mV p-p
M3G2815D				30	60	mV p-p
Efficiency (E_{FF})						
M3G2803R3S	1	I_{OUT} = 100% rated load Note 4	68	72		%
M3G2805S			75	77		%
M3G2805R2S			75	77		%
M3G2812S			75	78		%
M3G2815S			77	80		%
M3G2805D			75	78		%
M3G2812D			76	79		%
M3G2815D			77	80		%
Inhibit Input						
open circuit voltage	1,2,3	Note 1	3.0		5.0	V
drive current (sink)					100	µA
voltage range			-0.5		50	V
Synchronization Input						
frequency range	1,2,3	Ext. Clock on Sync. Input (Pin 4) Note 1	450		600	Khz
pulse high level			4.0		10.0	V
pulse low level			-0.5		0.5	V
pulse transition time			40			V/µS
pulse duty cycle			20		80	%
Current Limit Point Expressed as a percentage of full rated load current	1,2,3	V_{out} = 90% of Nominal, Note 4		125	135	%
Power dissipation, load fault (P_D)	1,2,3	Short Circuit, Overload, Note 8		14	20	W
Output response to step load changes (V_{TLD})	4,5,6	Half Load to/from Full Load, Notes 4,9	-300		300	mV pk
Recovery time, step load changes (T_{TLD})	4,5,6	Half Load to/from Full Load, Note 4,9,10		50	200	µS
Output response to step line changes (V_{TLN})	4,5,6	18V to/from 50V I_{OUT} = 100% rated load, Notes 1,4,11	-300		300	mV pk
Recovery time, step line changes (T_{TLN})	4,5,6	18V to/from 50V I_{OUT} = 100% rated load, Notes 1,4,10,11		50	200	µS
Turn-on Response						
Overshoot (V_{OS})	4,5,6	No Load, Full Load	1		10	%
Turn-on Delay (T_{DLY})		Notes 4,12			5	mS

For Notes to Specifications, refer to page 5

Electrical Performance Characteristics (continued)

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	
Capacitive Load (CL)						
M3G2803R3S	1	I_{OUT} = 100% rated load			2200	µF
M3G2805S		No effect on DC performance			1000	µF
M3G2805R2S		Notes 1, 4, 7			1000	µF
M3G2812S					180	µF
M3G2815S					120	µF
M3G2805D		Each output on duals			500	µF
M3G2812D					90	µF
M3G2815D					60	µF
Line Rejection	1	I_{OUT} = 100% rated load DC to 50KHz, Notes 1, 4	40	60		dB
Isolation	1	Input to Output or Any Pin to Case except pin 6, test @ 500VDC	100			MΩ
Device Weight					90	grams
MTBF		MIL-HDBK-217F2, SF, 35°C	5.0×10^6			Hours

Table I. Electrical Performance Characteristics - notes

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. Limit represents 80% of total rated output current. To achieve rated output power, the remaining 20% of the total rated output current must be provided by the other output.
4. Load current split equally between outputs on dual output models.
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 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 V_{OUT} = 90% of nominal.
9. Load step transition time ≥ 10 µSec.
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 µSec.
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 V_{OUT} = 90% of nominal.
13. For operation at temperatures between +85°C and +125°C, derate the maximum input voltage linearly from 60V to 40V and the maximum output power linearly from 100% to 75%.

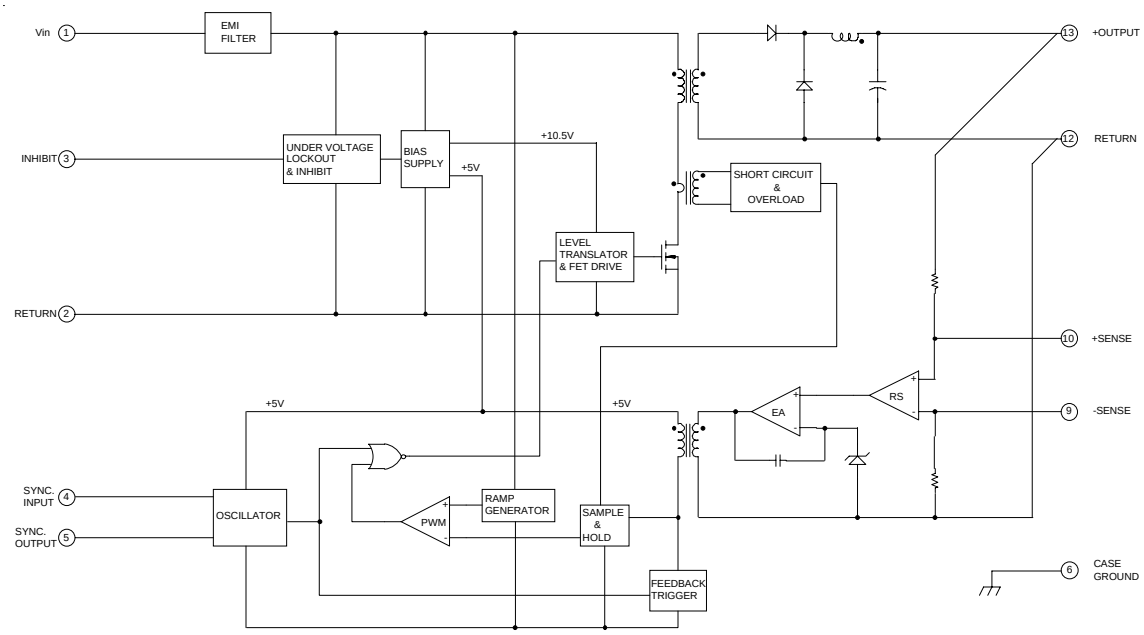
Radiation Performance Characteristics

Test	Conditions	Min	Typ	Unit
Total Ionizing Dose (Gamma)	MIL-STD-883, Method 1019 Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V	200	1000	KRads (Si)
Dose Rate (Gamma Dot) Temporary Saturation Survival	MIL-STD-883, Method 1023 Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V	1E8 4E10	 1E11	Rads (Si)/sec
Neutron Fluence	MIL-STD-883, Method 1017	8E12	1E13	Neutrons /cm^2
Single Event Effects SEU, SEL, SEGR, SEB	Heavy ions (LET) Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V	82		MeV•cm^2 /mg

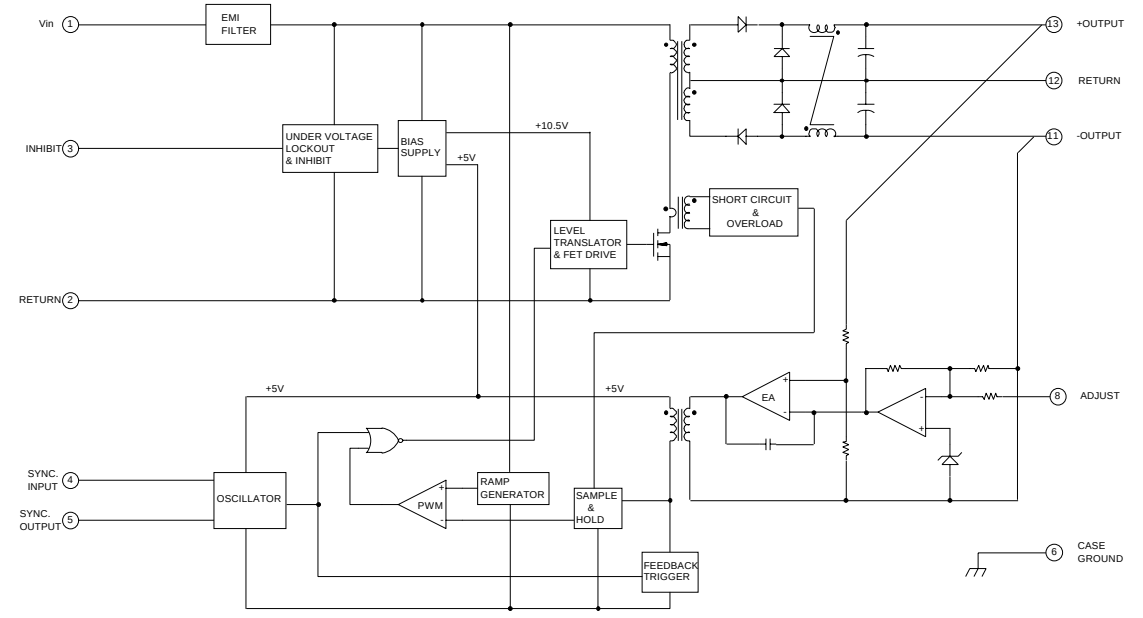
Device Screening

Test Inspection	Method	Condition
Element Evaluation	MIL-PRF-38534 Space Requirement	
Nondestructive Bond Pull	MIL-STD-883, Method 2023	
Internal Visual	MIL-STD-883, Method 2017	
Temperature Cycling	MIL-STD-883, Method 1010	C
Constant Acceleration	MIL-STD-883, Method 2001	A, Y1 axis only
PIND	MIL-STD-883, Method 2020	A
Electrical	In accordance with device specification	
Burn-in	MIL-STD-883, Method 1015	320 Hours
Final Electrical (Group A)	In accordance with device specification	
Seal Fine Leak Gross Leak	 MIL-STD-883, Method 1014	 A1 C
Radiographic	MIL-STD-883, Method 2012	
External Visual	MIL-STD-883, Method 2009	

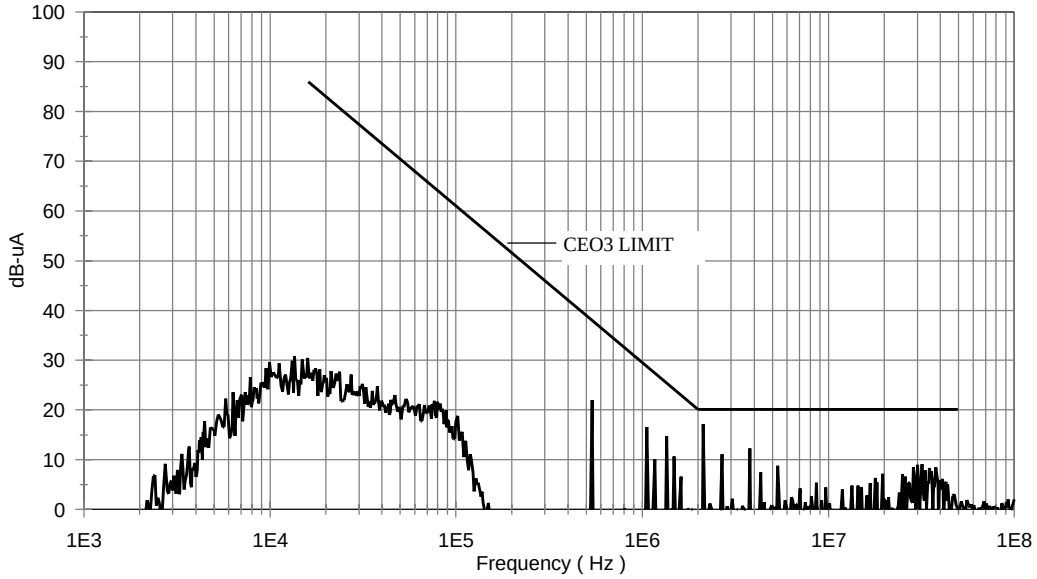
Block Diagram - Single Output



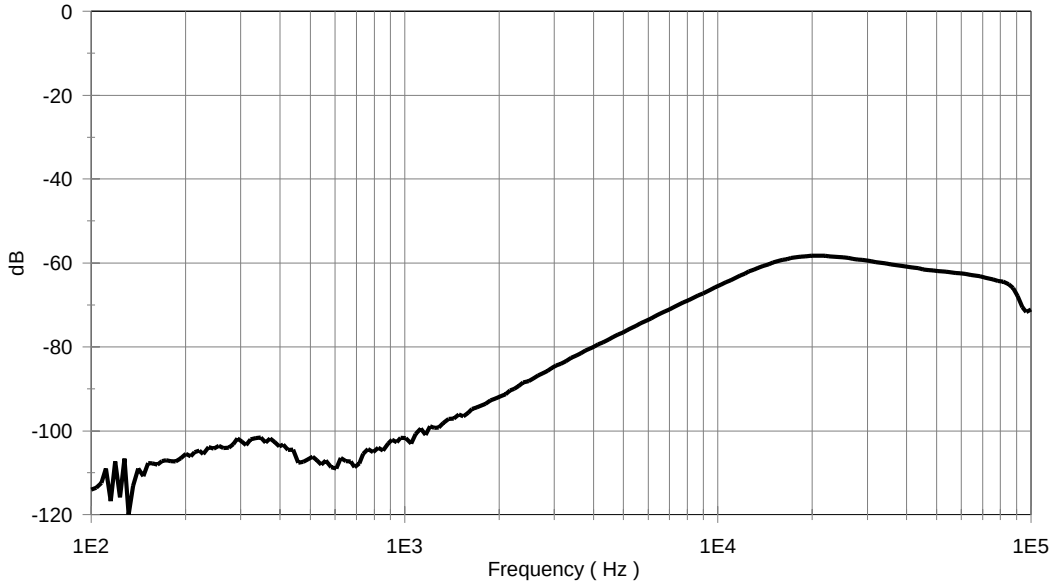
Block Diagram - Dual Output



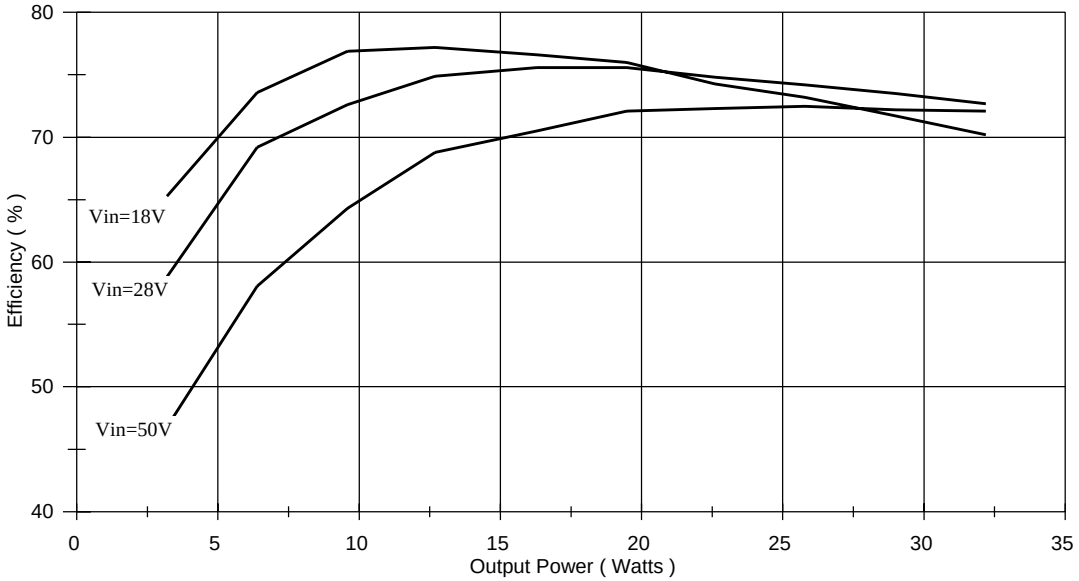
Conducted Emissions, Positive Lead



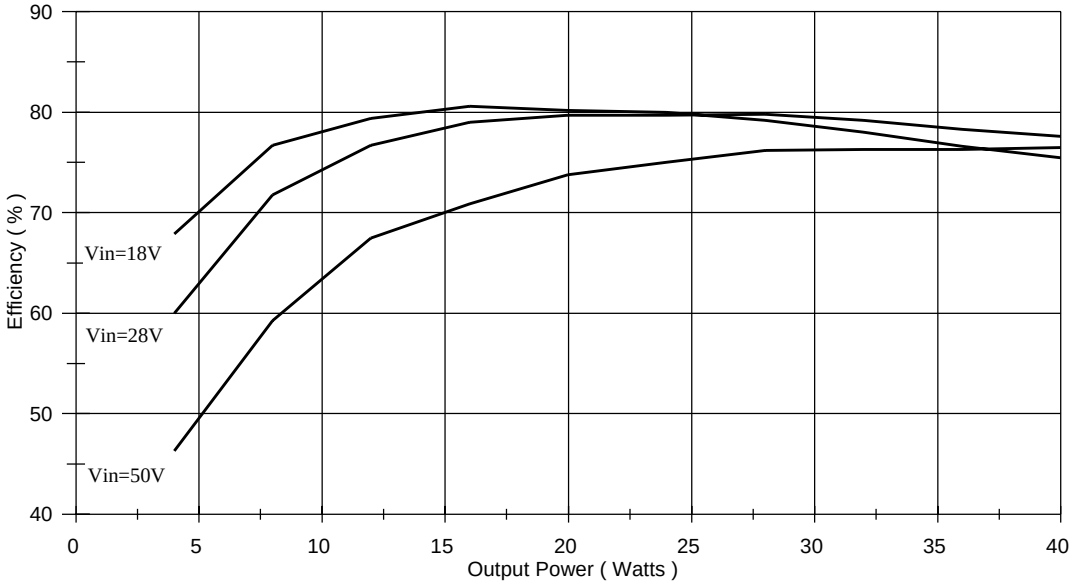
Line Rejection, 28Vdc + 8Vacp-p



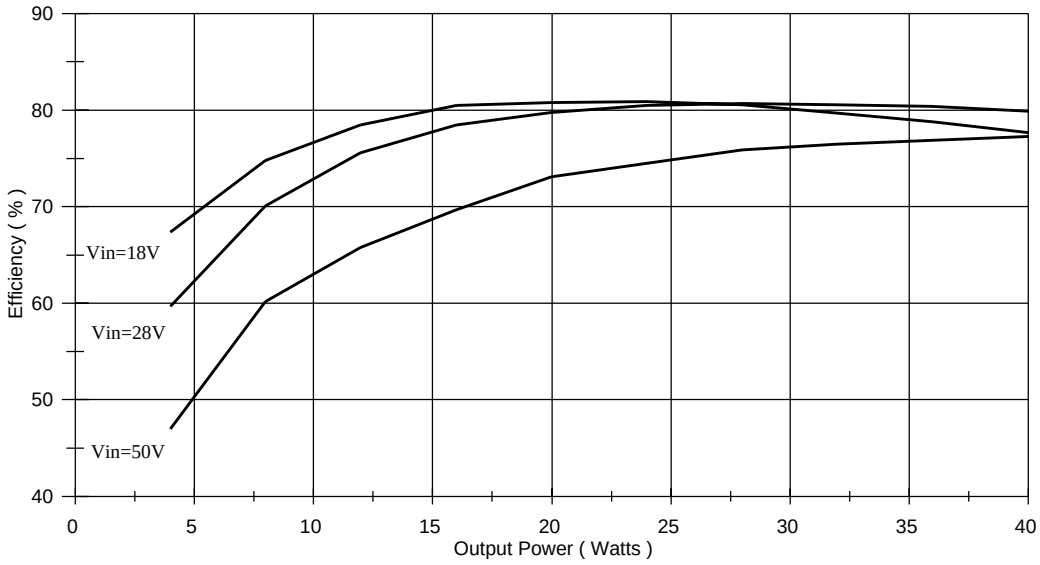
M3G2803R3S Efficiency



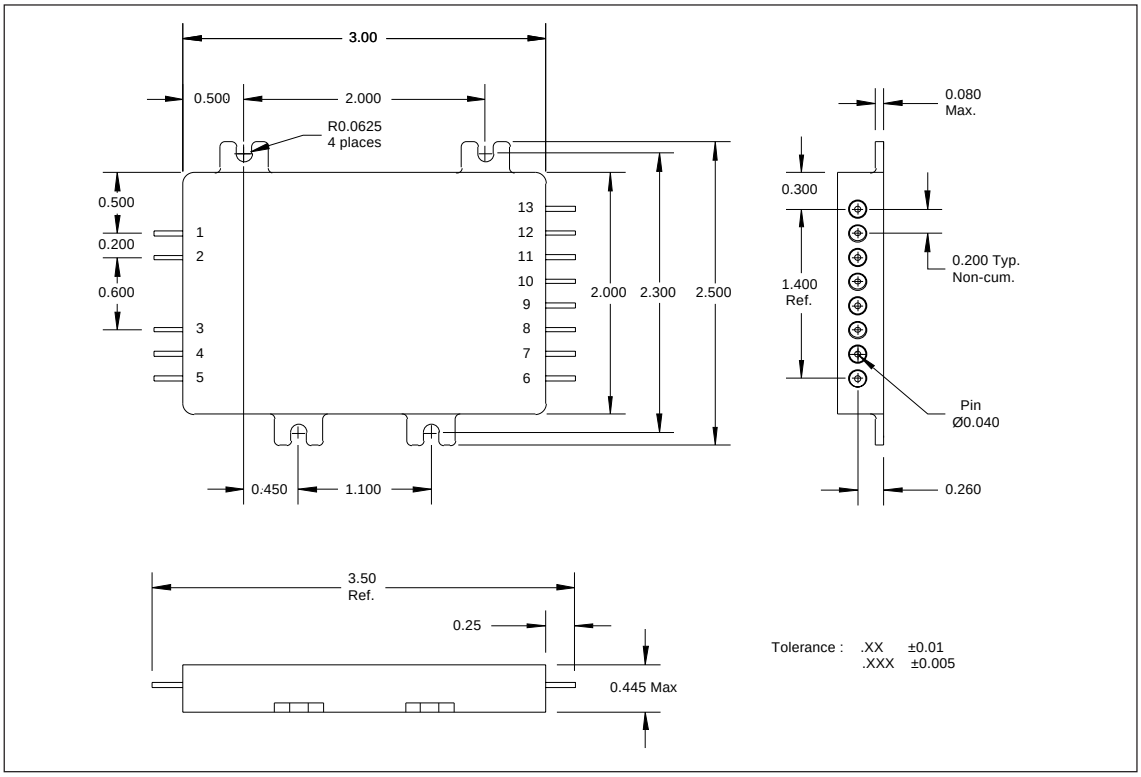
M3G2805S Efficiency



M3G2812S Efficiency



Mechanical Diagram



Pin Designation (Single/Dual)

Pin	Signal	Pin	Signal
Pin 1	+V Input	Pin 8	NC / Adjust
Pin 2	Input Return	Pin 9	-Sense / NC
Pin 3	Inhibit	Pin 10	+Sense / NC
Pin 4	Sync. Input	Pin 11	NC / -Output
Pin 5	Sync. Output	Pin 12	Output Return
Pin 6	Case Ground	Pin 13	+Output
Pin 7	NC		

Part Number

M3G 28 05 S

- Model
- Nominal Input Voltage
  - 28 = 28V
- Nominal Output Voltages
  - 03R3 = 3.3V, 05R2 = 5.2V
  - 05 = 5V, 12 = 12V, 15 = 15V
- Outputs
  - S = Single
  - D = Dual

International
IOR Rectifier

WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, Tel: (310) 322 3331
ADVANCED ANALOG: 2270 Martin Av., Santa Clara, California 95050, Tel: (408) 727-0500
Visit us at www.irf.com for sales contact information.