M3GB2803R7S

28V Input, 3.7V Output

HYBRID-HIGH RELIABILITY RADIATION HARDENED DC-DC CONVERTER

M3GB

Description

The M3GB2803R7S is a derivative of the M3GB Series of the International Rectifier HiRel family of products. The M3GB-Series of DC-DC converters are second generation design of the legacy M3G-Series product family but with enhanced overall performance. M3GB-Series is form, fit and functional equivalent to the first generation M3G-Series. It is designed to be backward compatible to the M3G-Series with the addition of an output voltage adjustment pin for the single output models. Much the same as the original M3G-Series, these 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

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 0.475" package constructed of an Aluminum/Silicon-Carbide (Al/SiC) base and an Alloy 48 ring frame and they weigh less than 100 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.

Non-flight versions of the M3GB-Series converters are available for system development purposes. Variations in electrical specifications and screening to meet custom requirements can be accommodated.

Features

- Total Dose > 200 kRads(Si) typically usable to > 300 kRads(Si)
- SEE Hardened to LET up to 82 MeV·cm^2/mg
- Internal EMI filter; Converter Capable of meeting MIL-STD-461C CE03
- Low Weight < 100 grams
- Magnetically Coupled Feedback
- 18V to 50V DC Input Range
- Up to 30W Output Power
- Single Output Models 3.7V
- High Efficiency - to 75%
- -55°C to +125°C Operating Temperature Range
- 100MΩ @ 100VDC Isolation
- Under-Voltage Lockout
- Short Circuit and Overload Protection
- Remote Sense
- Adjustable Output Voltage
- Synchronization Input and Output
- External Inhibit
- > 7,000,000 hour MTBF

Applications

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

Circuit Description

The M3BG-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.

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.

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 15.3 volts. The 1.2V 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 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.

Design Methodology

The M3GB-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-1547 and MIL-STD-975 (except for the CDR type ceramic capacitors, where capacitors with 50V ratings may be used with voltage stresses of less than 10V). Careful sizing of decoupling capacitors and current limiting resistors minimizes the possibility of photo-current burn-out. 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 and RadSPICE were used extensively to predict and optimize circuit performance for both beginning and end-of-life. Thorough design analyses include Worst Case, Stress, Thermal, Failure Modes and Effects (FMEA) and Reliability (MTBF).

Specifications

Absolute Maximum Ratings		Recommended Operating Conditions	
Input Voltage	-0.5V_{DC} to +80V_{DC}	Input Voltage	+18V_{DC} to +60V_{DC}
Output power	Internally limited	Input Voltage [1]	+18V_{DC} to +45V_{DC}
Lead Temperature	+300°C for 10 seconds	Output power	0 to Max. Rated
Operating temperature	-55°C to +135°C	Operating temperature[2]	-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
[2] For operation at +125°C see table Note 10

Electrical Performance Characteristics

Parameter	Symbol	Conditions -55°C ≤ T_C ≤ +85°C V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Group A Subgroup	Device type	Limits Min	Limits Max	Unit
Output Voltage	V_{OUT}	I_{OUT} = 8.1A	1	01	3.68	3.73	V_{DC}
			2,3		3.63	3.77	
Output Voltage with Adjust	V_{OUT_ADJ}	Remote sense closed, Pin 8 shorted to Pin 6, I_{OUT} = 8.1A	1, 2, 3	01	3.75	3.95	V
Output Current	I_{OUT}	V_{IN} = 18, 28, 50 Volts, Note 1			0	8.1	A
Output Ripple Voltage	V_{RIP}	I_{OUT} = 8.1A , Note 2	1,2,3	01		35	mV p-p
Line Regulation	VR_{LINE}	V_{IN} = 18, 28, 50 Volts I_{OUT} = 0, 50%, 100% rated	1,2,3	01	-10	10	mV
Load Regulation	VR_{LOAD}	V_{IN} = 18, 28, 50 Volts I_{OUT} = 0, 50%, 100% rated	1,2,3	01	-19	19	mV
Total Regulation	VR	All conditions of Line, Load and temperatures.	1,2,3	01	3.63	3.77	V
Input Current	I_{IN}	I_{OUT} = 0, Pin 3 open	1,2,3	01		80	mA
		Inhibit (pin 3) shorted to Input return (pin 2)	1,2,3			5	mA
Inhibit input	INH_{IN}	Open circuit voltage, Note 3	---	01	3.0	5.0	V
		Drive current (sink) , Note 3				100	µA
		Voltage range , Note 3			-0.5	50	V
Efficiency	E_{FF}	I_{OUT} = 8.1A	1,2,3	01	72		%
Isolation	ISO	Input to Output or any Pin to Case except Pin 10, test @ 100 Vdc	1	01	100		MΩ
Maximum Capacitive Load	C_L	I_{OUT} = 8.1A, T_C = +25ºC No effect on DC performance, Note 3, 4	---	01		2200	µF
Power Dissipation Load Fault	P_D	Short Circuit, Note 5	1,2,3	01		18	W
		Overload , Note 5					
Current Limit Point	I_{lm}	Output Current @ V_{OUT} = 3.33V Note 9	1	01	9.6	10.3	A
			2,3		9.5	10.5	
Switching Frequency	F_S	Sync Input (Pin 4) open	1,2,3	01	475	525	kHz

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

Electrical Performance Characteristics (continued)

Parameter	Symbol	Conditions -55°C ≤ T_C ≤ +85°C V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Group A Subgroup	Device type	Limits Min	Limits Max	Unit
Switching Frequency Range	F_{SYNC}	Ext. Clock on Sync. Input (Pin 4)	1,2,3	01	450	600	kHz
Sync Input	$SYNC_{IN}$	Pulse high level, Note 3	---	01	4	10	V
		Pulse level low, Note 3			-0.5	0.5	V
		Pulse transition time, Note 3			40		V/µs
		Pulse duty cycle, Note 3			20	80	%
UVR Threshold	V_{UVR}	Gradually Increasing Vin voltage until output enables (UVR)	1	01	16.4	16.6	V
			2,3		16.3	16.7	
UVLO Threshold	V_{UVL}	Gradually Dropping Vin voltage until output disables (UVL)	1	01	15.1	15.5	V
			2,3		15.0	15.6	
Output response to step transient load changes	VO_{TLOAD}	50% load to/from 100% load, any output, Note 6	4, 5, 6	01	-300	+300	mVpk
Recovery time, step transient load changes	TT_{LOAD}	50% load to/from 100% load, any output, Note 6, 7	4, 5, 6	01		200	µs
Output response to transient step line changes	VO_{TLINE}	Input step 22V to/from 34Vdc, I_{OUT} = 8.1A, Note 3, 7, 8	---	01	-200	+200	mVpk
Recovery time, step transient line changes	TT_{LINE}	Input step 22V to/from 34Vdc, I_{OUT} = 8.1A, Note 3, 7, 8	---	01		200	µs
Turn-On Overshoot	VT_{onos}	I_{OUT} = 0, 8.1A, Note 9	4, 5, 6	01		74	mVpk
Turn-On Delay	T_{onD}	I_{OUT} = 0, 8.1A, Note 9	4, 5, 6	01	1	5	ms

Notes: Electrical Performance Characteristics Table

1. Parameter verified during line and load regulation tests.
2. Guaranteed for a DC to 20 MHz bandwidth. Tested using a 20 KHz to 10 MHz bandwidth.
3. Parameter is guaranteed to the limits specified in table I by design, but not tested. Limits apply to the operating range specified in Table I, unless otherwise specified. No Group A subgroups are specified for this test.
4. 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.
5. Overload power dissipation is defined as the device power dissipation with the load set such that V_{OUT} = 90% of nominal
6. Load step transition time ≥ 10 µS.
7. Recovery time is measured from the initiation of the transient to where V_{OUT} has returned to within ±1% of its steady state value.
8. Line step transition time ≥ 100 µS.
9. Turn-on delay time is measured 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.
10. Although operation at temperatures between +85°C and +125°C is guaranteed, no parametric limits are specified.

Fig 1. Block Diagram - Single Output

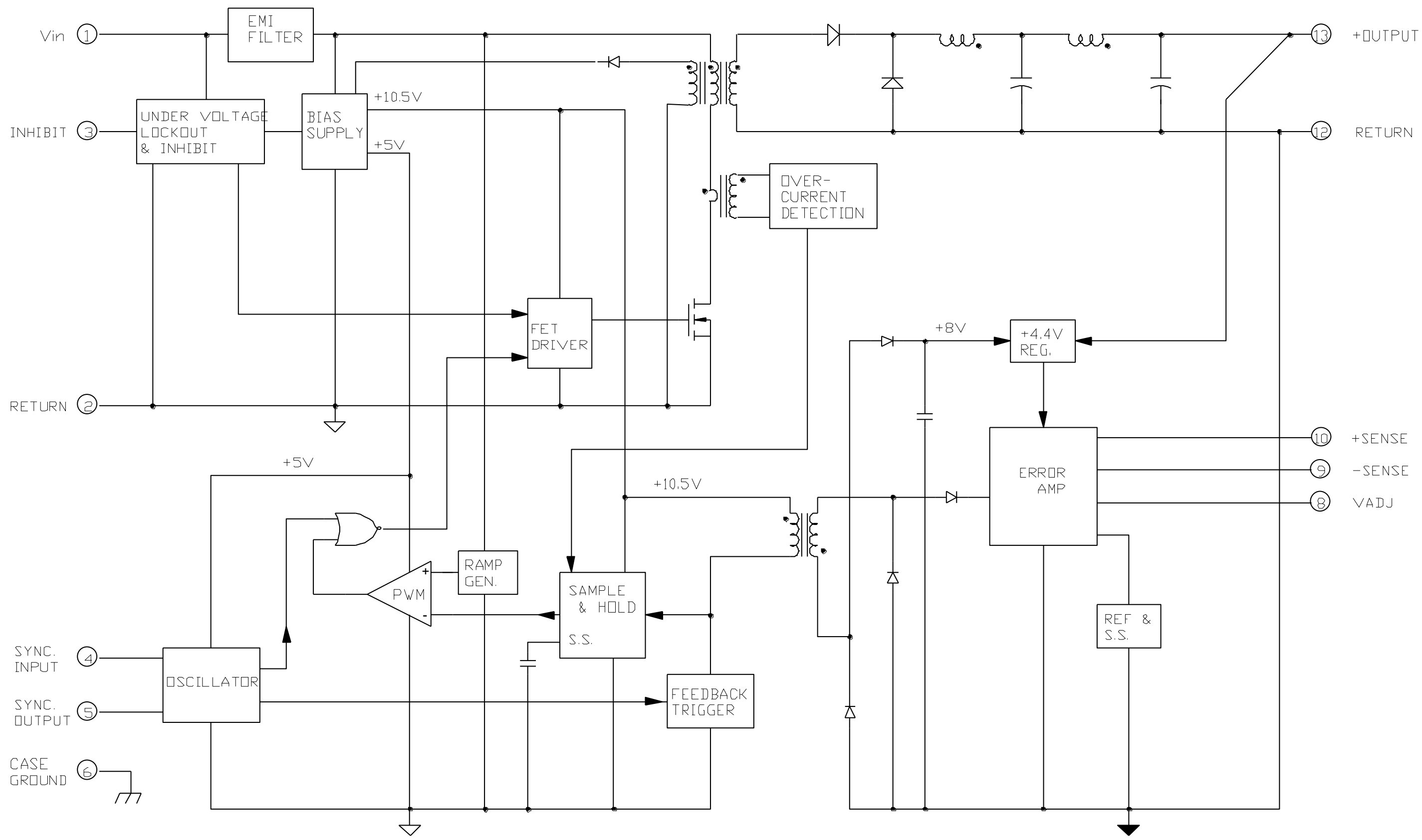
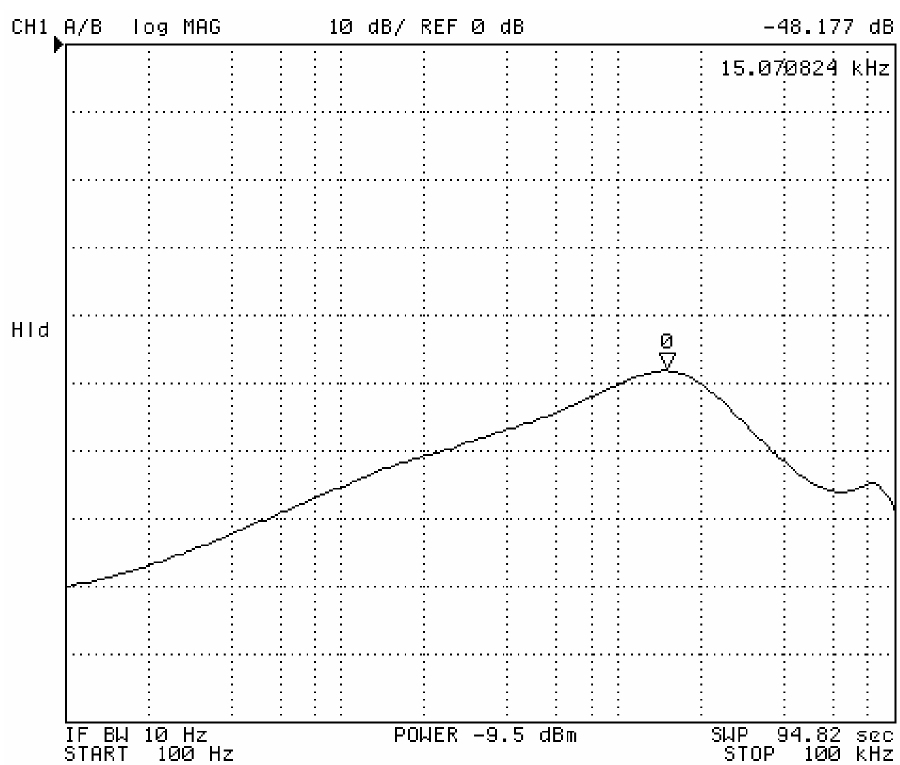


Fig 2. Typical Conducted Emissions, Positive Lead

Fig 3. Typical Line Rejection



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	300	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 (supported by analysis)	1E8 4E10	 1E11	Rads (Si)/sec
Neutron Fluence	MIL-STD-883, Method 1017 (supported by analysis)	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} = 18, 28, 50V	82		MeV·cm^2/mg

Application Notes

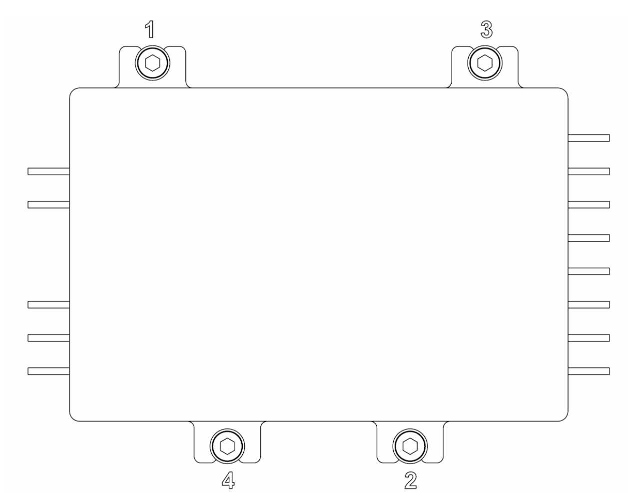
A) Attachment of the Converter:

The following procedure is recommended for mounting the converter for optimum cooling and to circumvent any potential damage to the converter.

Ensure that flatness of the plate where M3GB converter to be mounted is no greater than 0.003" per linear inch. It is recommended that a thermally conductive gasket is used to promote the thermal transfer and to fill any voids existing between the two surfaces. IR HiRel recommends Sil-Pad 2000 with the thickness of 0.010". The shape of the gasket should match the footprint of the converter including the mounting flanges. The gasket is available from IR HiRel. The M3GB-Series converter requires either M3 or 4-40 size screws of attachment purposes.

The procedure for mounting the converter is as follows:

1. Check the mounting surfaces and remove foreign material, burrs if any or anything that may interfere with the attachment of the converter.
2. Place the gasket on the surface reserved for the converter and line it up with the mounting holes.
3. Place the converter on the gasket and line both up with mounting holes.
4. Install screws using appropriate washers and tighten by hand (~ 4 in·oz) in the sequence shown below.



5. Tighten the screws with an appropriate torque driver. Torque the screws up to 6 in·lb in the sequence shown above.

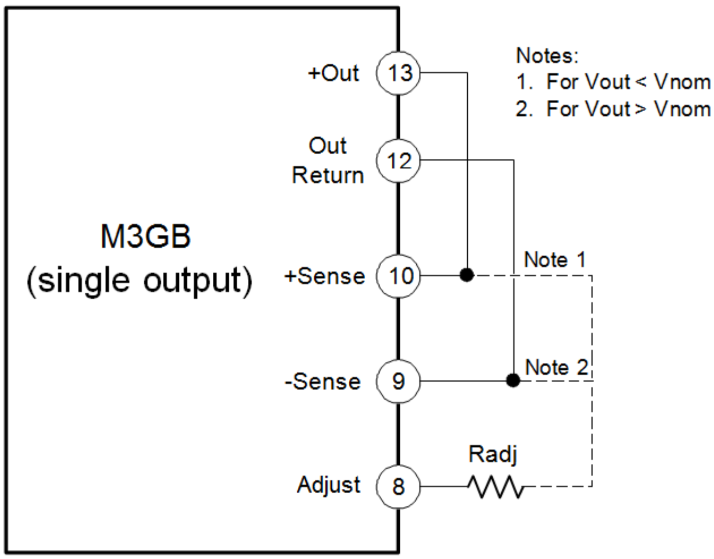
B) Output Voltage Adjustment

Single Output:

To adjust the output voltage of the single output models, a resistor (R_{ADJ}) is connected between the Adjust pin (Pin 8) and either the positive or negative remote sense pins, depending on whether the output voltage is to be adjusted higher or lower than the nominal set-point. This allows the outputs to be reliably adjusted by approximately +10% to -20% of the nominal output voltage. Refer to Fig. 7 and use equations provided to calculate the required resistance (R_{ADJ}).

Note: The output voltage adjust equation does not work as described for the 3.7V Single model. The adjust range for 3.7V model is limited to 3.595V to 3.940V.

Fig 7. Configuration for Adjusting Single Output Voltage



For **all Single Output Models**, to adjust the output voltages higher:

$$R_{ADJ} = \frac{10 \times (V_{NOM} - 2.5)}{V_{OUT} - V_{NOM}} - 50$$

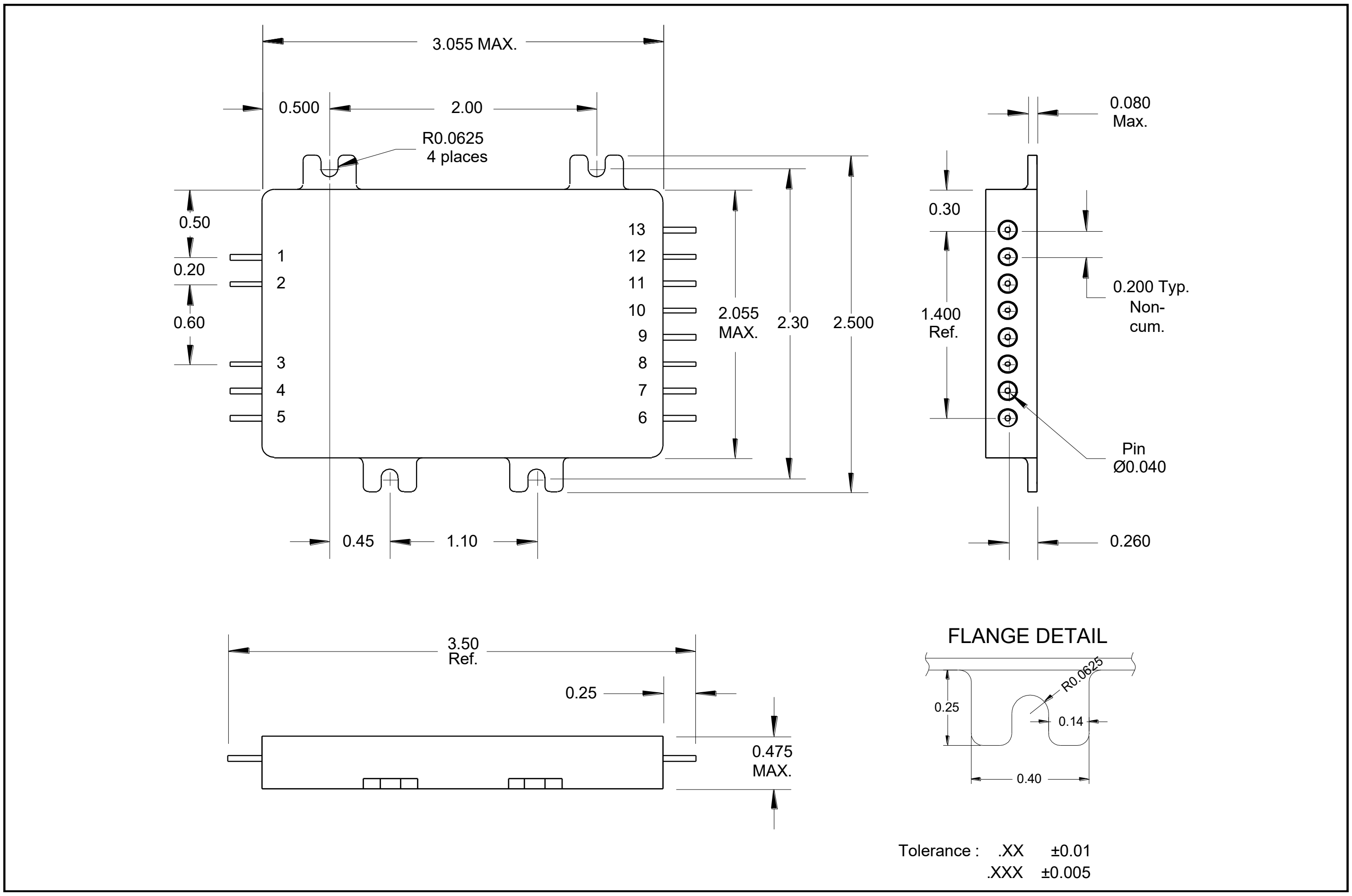
Where: R_{ADJ} is in kOhms
R_{ADJ} is connected to the -Out pin and $V_{NOM} < V_{OUT} < 1.1V_{NOM}$ (Fig. 7, Note 2)
V_{NOM} is the nominal output voltage with the Adjust Pin left open
V_{OUT} is the desired output voltage

For **all Single Output Models**, to adjust the output voltages lower:

$$R_{ADJ} = \frac{4 \times (V_{NOM} - 2.5) \times (V_{OUT} - 2.5)}{V_{NOM} - V_{OUT}} - 50$$

Where: R_{ADJ} is in kOhms
R_{ADJ} is connected to the +Out pin and $0.8V_{NOM} < V_{OUT} < V_{NOM}$ (Fig. 7, Note 1)
V_{NOM} is the nominal output voltage with the Adjust Pin left open
V_{OUT} is the desired output voltage

Mechanical Outline



Pin Designation (Single)

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

Device Screening

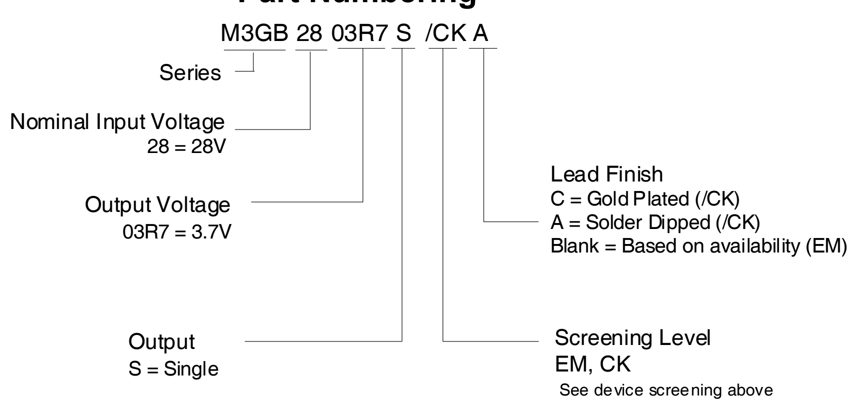
Part Number Designator		/EM ①	/CK ②
Compliance Level	**MIL-PRF-38534**	N/A	**K level compliant**
Certification Mark		—	**CK**
Screening Requirement	**MIL-STD-883 Method**	—	—
Temperature Range	—	Ambient	-55°C to +85°C
Element Evaluation	MIL-PRF-38534	N/A	Class K
Non-Destructive Bond Pull	2023	N/A	Yes
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	Ambient	-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** 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.

Part Numbering



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www.infineon.com/irhirel

Infineon Technologies Service Center: USA Tel: +1 (866) 951-9519 and International Tel: +49 89 234 65555
Leominster, Massachusetts 01453, USA Tel: +1 (978) 534-5776
San Jose, California 95134, USA Tel: +1 (408) 434-5000
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