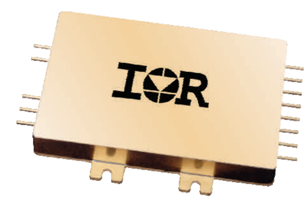
An Infineon Technologies Company

M3N-SERIES

HYBRID-HIGH RELIABILITY RADIATION HARDENED DC-DC CONVERTER

100V Input, Single/Dual Output



M3N

Description

M3N-Series is part of the International Rectifier HiRel family of products. The M3N-Series of DC-DC converters are radiation hardened, high reliability converters designed for radiation environments such as those encountered by geosynchronous orbit satellites, deep space probes and communication systems. Features of the M3N-Series include up to 40 watt output power, small size, low weight and a high tolerance to total ionizing dose (TID) and heavy ion single event effects (SEE). They are designed to withstand environmental stresses such as temperature extremes, mechanical shock and vibration. All components are derated to meet the requirements of MIL-STD-975, MIL-STD-1547 and NASA EEE-INST-002. Extensive documentation including thermal, electrical stress, reliability (MTBF), worst case analyses are available.

The converters incorporate a fixed frequency single ended forward topology with magnetic feedback and an internal EMI filter. These converters are capable of meeting the conducted emissions and susceptibility requirements of MIL-STD-461F. They include an external inhibit port and an adjustable output voltage pin. They are encased in a hermetic 3.0" L x 2.0" W x 0.445" H steel package and weigh less than 125 grams. The package utilizes rugged ceramic feed-through copper core pins and is sealed.

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 M3N-Series converters are available for system development purposes. Variations in electrical specifications and screening to meet custom requirements can be accommodated.

Features

- Total Dose guaranteed to 100 kRads(Si)
- SEE Hardened to LET up to 64 MeV.cm^2/mg
- Low Weight < 125 grams
- Low Input and Output Noise
- Magnetically Coupled Feedback
- 65V to 110V DC Input Range
- Up to 40W Output Power
- Single and Dual Output Models Include 3.3, 5, 12, 15 and ±5, ±12 and ±15V
- High Efficiency - to 83%
- -55°C to +125°C Operating Temperature Range
- 100MΩ @ 100VDC Isolation
- Short Circuit and Overload Protection
- Remote Sense on Single Output Models
- Adjustable Output Voltage
- 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 System

Circuit Description

The M3N-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.

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 current. 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 62 volts and will shut down when the input voltage drops below 57.5 volts. The 4.5V 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. The output voltage of dual output models can be adjusted by a single external resistor.

Design Methodology

The M3N-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, MIL-STD-1547 and NASA EEE-INST-002 except for 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 Radiation Susceptibility (TREE), 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 +120V_{DC}	Input Voltage range [1]	+65V_{DC} to +110V_{DC}
Output power	Internally limited	Output power	0 to Max. Rated
Lead Temperature	+300°C for 10 seconds	Operating temperature [2]	-55°C to +125°C
Operating temperature	-55°C to +135°C	Operating temperature[1]	-55°C to +70°C
Storage temperature	-55°C to +135°C		

[1] Meets de-rating 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} = 100V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Input Voltage (V_{IN})			65	100	110	V
Output Voltage (V_{OUT}) M3N10003R3S M3N10005S M3N10012S M3N10015S M3N10005D M3N10012D M3N10015D	 1 1 1 1 1 1 1	 I_{OUT} = 100% rated load Note 4	 3.28 4.98 11.95 14.94 ±4.98 ±11.95 ±14.94	 3.30 5.00 12.00 15.00 ±5.00 ±12.00 ±15.00	 3.32 5.02 12.05 15.06 ±5.02 ±12.05 ±15.06	V
M3N10003R3S M3N10005S M3N10012S M3N10015S M3N10005D M3N10012D M3N10015D	2,3 2,3 2,3 2.3 2,3 2,3 2,3	I_{OUT} = 100% rated load Note 4	3.24 4.93 11.84 14.80 ±4.93 ±11.84 ±14.80		3.36 5.07 12.16 15.20 ±5.07 ±12.16 ±15.20	
Output power (P_{OUT}) M3N10003R3S All Others	1,2,3	V_{IN} = 65, 100, 110 Volts, Note 2	 0 0		 30 40	W
Output current (I_{OUT}) M3N10003R3S M3N10005S M3N10012S M3N10015S M3N10005D M3N10012D M3N10015D	1,2,3	V_{IN} = 65, 100, 110 Volts, Note 2 Either Output, Note 3 Either Output, Note 3 Either Output, Note 3	 0 0 0 0 0 0 0		 9.10 8.00 3.34 2.67 6.40 2.67 2.14	A
Line regulation (VR_{LINE})	1,2,3	V_{IN} = 65, 100, 110 Volts I_{OUT} = 0, 50%, 100% rated, Note 4	-20		20	mV
Load regulation (VR_{LOAD})	1,2,3	I_{OUT} = 0, 50%, 100% rated, Note 4 V_{IN} = 65, 100, 110 Volts	-0.5		-0.5	%
Cross regulation (VR_{CROSS}) M3N10005D M3N10012D M3N10015D	1,2,3	Duals only, Note 5 V_{IN} = 65, 100, 110 Volts	 -5.0 -3.0 -2.0		 5.0 3.0 3.0	%

For Notes to Electrical Performance Characteristics, refer to page 5

Electrical Performance Characteristics (continued)

Parameter	Group A Subgroup	Conditions $-55°C \le T_C \le +85°C$ V_{IN} = 100V DC ± 5%, C_L = 0 unless otherwise specified	Limits Min	Limits Nom	Limits Max	Unit
Input current (I_{IN})	1,2,3	I_{OUT} = 0, Pin 3 open Pin 3 shorted to Pin 2		 2.0	50 5.0	mA
Switching frequency (F_S)	1,2,3	Sync. Input (Pin 4) open	450	500	550	kHz
Output ripple (V_{RIP}) M3N10003R3S M3N10005S M3N10012S M3N10015S M3N10005D M3N10012D M3N10015D	1,2,3	V_{IN} = 65, 100, 110 Volts I_{OUT} = 100% rated load Notes 4, 6		 15 20 25 25 20 30 30	 35 50 60 80 50 60 60	mV p-p
Efficiency (E_{FF}) M3N10003R3S M3N10005S M3N10012S M3N10015S M3N10005D M3N10012D M3N10015D	1,2,3	I_{OUT} = 100% rated load Note 4	 70 77 78 79 77 78 79	 75 81 82 83 81 82 83		%
Inhibit Input open circuit voltage drive current (sink) voltage range		Note 1	 3.0 -0.5		 5.0 100 50	 V µA V
Synchronization Input frequency range pulse high level pulse low level pulse transition time pulse duty cycle		Ext. Clock on Sync. Input (Pin 4) Note 1	 450 4.0 -0.5 40 20		 600 10 0.5 80	 kHz V V V/µs %
Current Limit Point Expressed as a percentage of full rated load current	1,2,3	V_{OUT} = 90% of Nominal, Note 4			145	%
Power dissipation, load fault (P_D)	1,2,3	Short Circuit, Overload, Note 8			20	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		50	200	µs
Output response to step line changes (V_{TLN})		65V to/from 110V I_{OUT} = 100% rated load, Notes 1,4,11	-300		300	mVpk
Recovery time, step line changes (T_{TLN})		65V to/from 110V I_{OUT} = 100% rated load, Notes 1,4,10,11		50	200	µs

For Notes to Electrical Performance Characteristics, refer to page 5

Electrical Performance Characteristics (continued)

Parameter	Group A Subgroup	Conditions $-55°C \le T_C \le +85°C$ V_{IN} = 100V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Turn-on Response Overshoot (V_{OS}) Turn-on Delay (T_{DLY})	4,5,6	No Load, Full Load Notes 4,12	 1.0		 10 5.0	 % ms
Capacitive Load (C_L) M3N10003R3S M3N10005S M3N10012S M3N10015S M3N10005D M3N10012D M3N10015D		I_{OUT} = 100% rated load No effect on DC performance Notes 1, 4, 7 Each output on duals			 2200 1000 180 120 500 90 60	µF
Line Rejection		I_{OUT} = 100% rated load DC to 50kHz, Notes 1, 4	40	50		dB
Isolation	1	Input to Output or Any Pin to Case except Pin 6, test @ 200VDC	100			MΩ
Device Weight					125	g
MTBF		MIL-HDBK-217F2, SF, 35°C, Note 14	5.0×10^6			Hrs

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 its outputs.
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 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 3) to the point where V_{OUT} = 90% of nominal.
13. Although operation at temperatures between +85°C and +125°C is guaranteed, no parametric limits are specified.
14. For Class k devices.

Fig 1. Block Diagram - Single Output

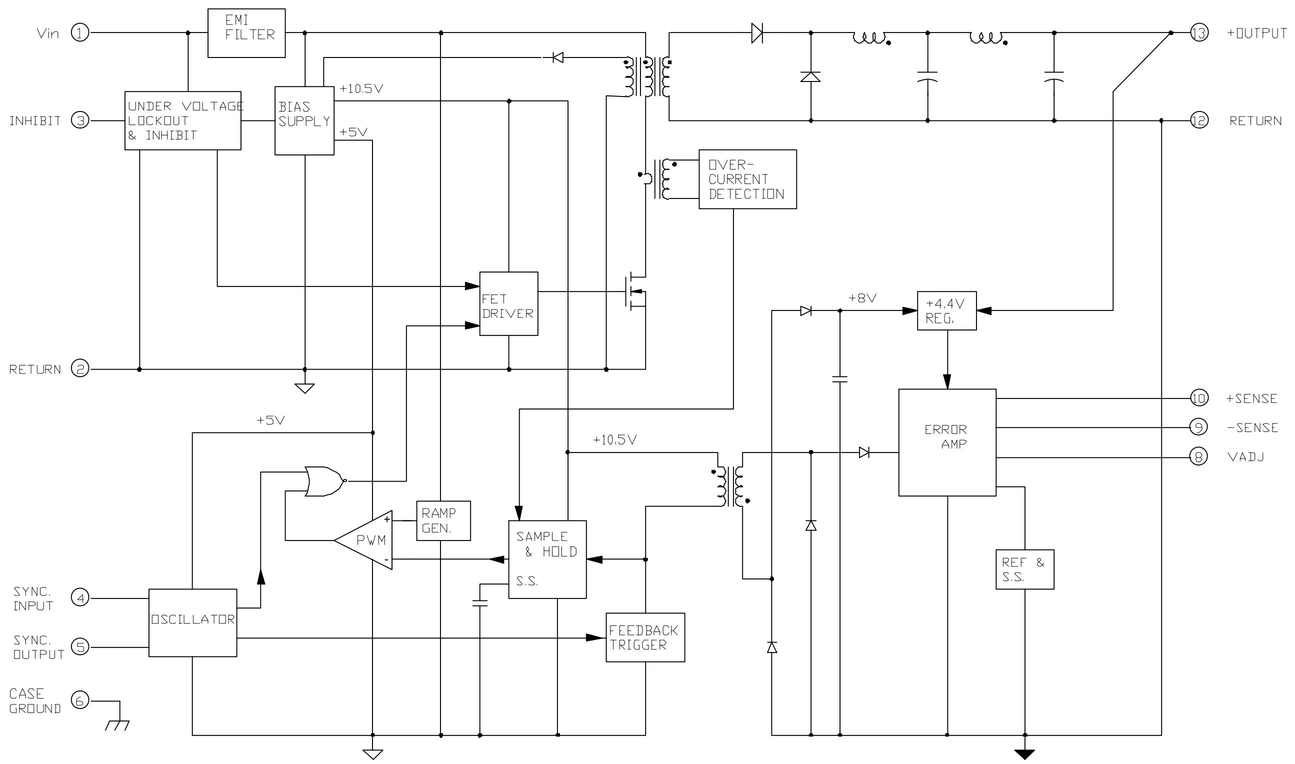
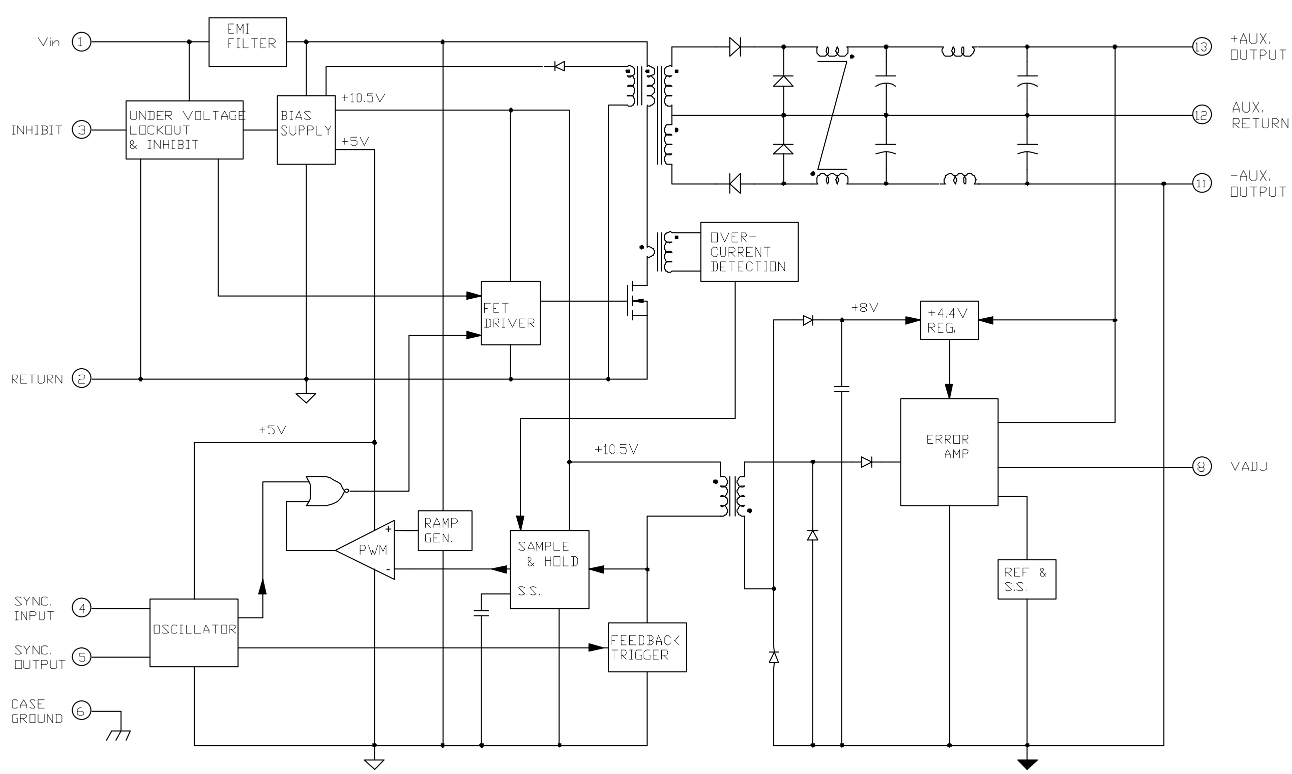


Fig 2. Block Diagram - Dual Output



Radiation Performance Characteristics

Test	Conditions	Min	Typ	Max	Unit
Total Ionizing Dose (Gamma)	MIL-STD-883, Method 1019 Operating bias applied during exposure, Full Rated Load, V_{IN} = 100V	100		450	kRads(Si)
Single Event Effects SEU, SEL, SEGR, SEB①	Heavy ions (LET) Operating bias applied during exposure, Full Rated Load, V_{IN} = 100V ②	58	61	64	MeV•cm^2/mg

Notes:
① Output perturbation is less than ± 5% of nominal output voltage.
② Beam conditions: LET = 61 ± 5% MeV•cm^2/mg.

Application Notes

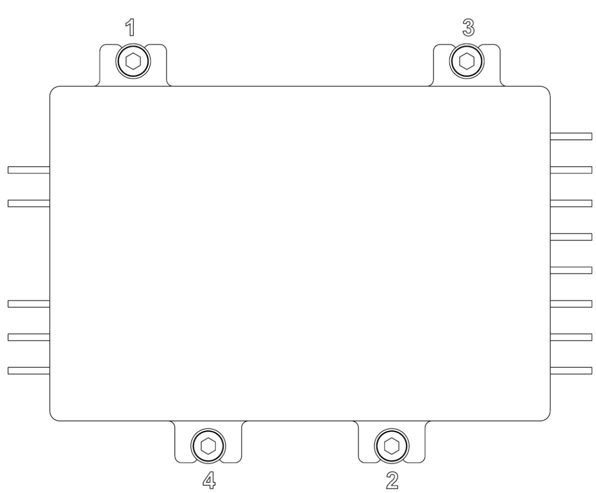
A) Attachment of the Converter:

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 M3N 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 M3N-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 below.



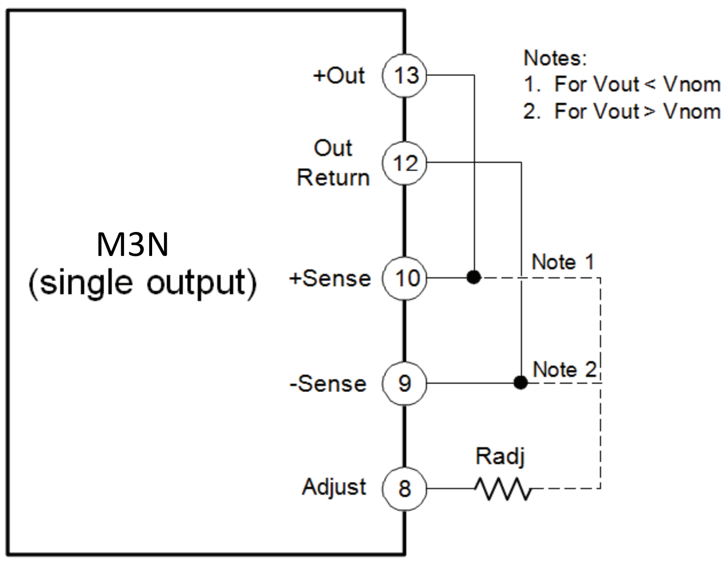
B) Output Voltage Adjustment

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. 3 and use equations provided to calculate the required resistance (R_{ADJ}).

Note: The output voltage adjust equation does not work as described for the 3.3V Single model. The adjust range for 3.3V model is limited to 3.252V to 3.460V.

Fig 3. 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. 3, 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:

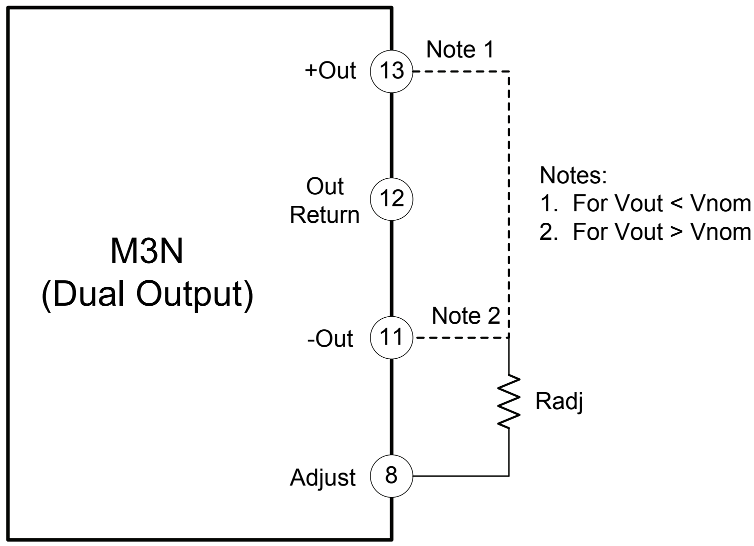
$$R_{ADJ} = \frac{4 \times (V_{NOM} - 2.5) \times (V_{OUT} - 2.5)}{V_{NOM} - V_{OUT}} - 50$$

Where: R_{ADJ} is in kOhms
R_{ADJ} is connected to the +Out pin and $0.8V_{NOM} < V_{OUT} < V_{NOM}$ (Fig. 3, Note 1)
V_{NOM} is the nominal output voltage with the Adjust Pin left open
V_{OUT} is the desired output voltage

Dual Output:

The dual output voltage of the dual output models, a resistor (R_{ADJ}) is connected between the Adjust pin (Pin 8) and either output. This allows the outputs to be reliably adjusted by approximately +10% to -20% of the nominal output voltage. Refer to Fig. 4 and use equations provided to calculate the required resistance (R_{ADJ}).

Fig. 4. Configuration for Adjusting Dual Output Voltage



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

$$R_{ADJ} = \frac{10 \times (V_{NOM} - 1.25)}{V_{OUT} - V_{NOM}} - 75$$

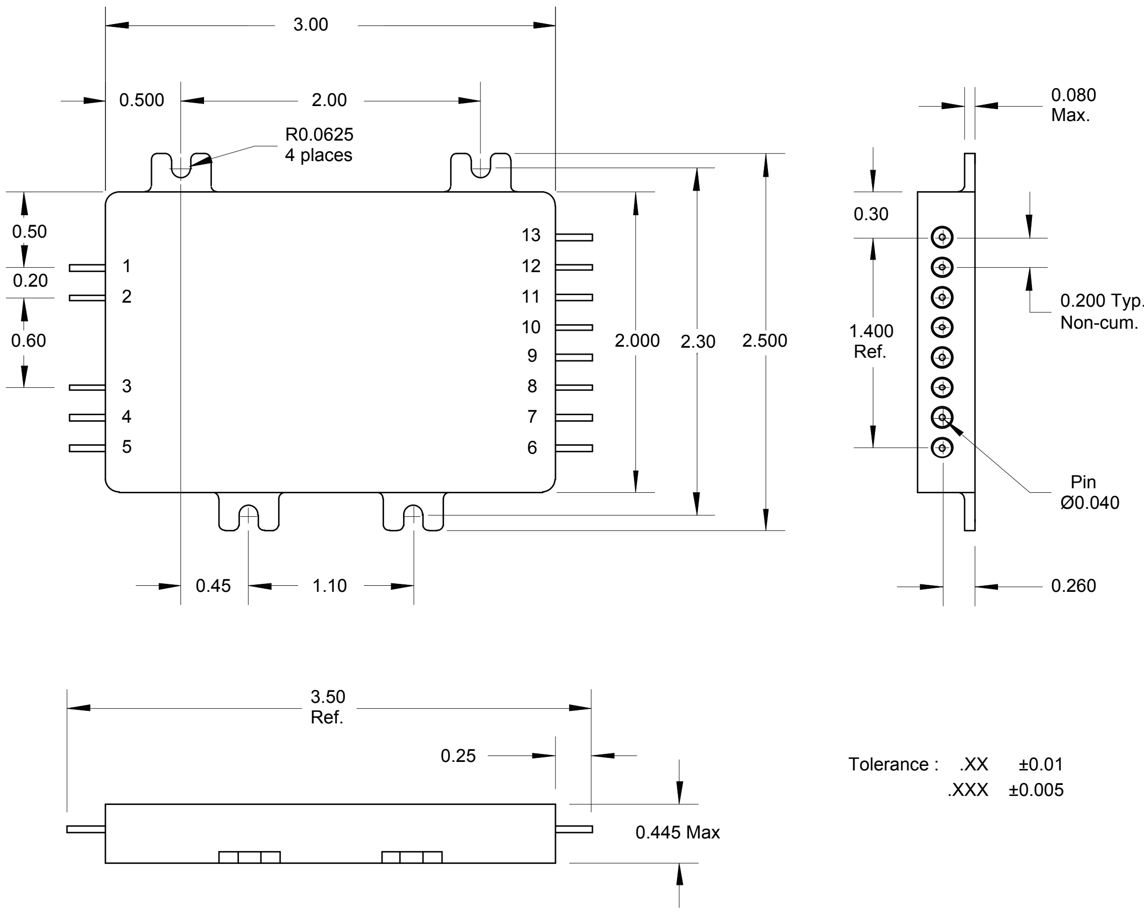
Where: R_{ADJ} is in kOhms
R_{ADJ} is connected to the -Out pin and $V_{NOM} < V_{OUT} < 1.1V_{NOM}$ (Fig. 4, Note 2)
V_{NOM} is the nominal magnitude of the output voltages with the Adjust pin left open
V_{OUT} is the desired magnitude of the output voltages

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

$$R_{ADJ} = \frac{8 \times (V_{NOM} - 1.25) \times (V_{OUT} - 1.25)}{V_{NOM} - V_{OUT}} - 75$$

Where: R_{ADJ} is in kOhms
R_{ADJ} is connected to the +Out pin and $0.8V_{NOM} < V_{OUT} < V_{NOM}$ (Fig. 4, Note 1)
V_{NOM} is the nominal magnitude of the output voltages with the Adjust pin left open
V_{OUT} is the desired magnitude of the output voltages

Mechanical Outline



Pin Designation (Single/Dual)

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

Device Screening

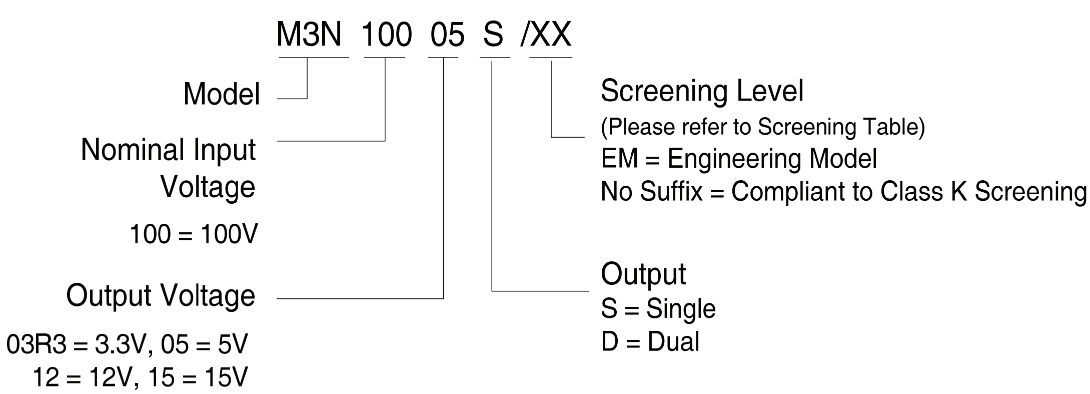
Requirement	MIL-STD-883 Method	EM ①	No Suffix ②
Temperature Range	—	-55°C to +85°C	-55°C to +85°C
Element Evaluation	MIL-PRF-38534	N/A	Class K
Non-Destructive Bond Pull	2023	N/A	Yes
Internal Visual	2017	①	Yes
Temperature Cycle	1010	Cond C	Cond C
Constant Acceleration	2001, Y1 Axis	3000 Gs	3000 Gs
PIND	2020	N/A	Cond A
Burn-In	1015	48 hrs @ 125°C	320 hrs @ 125°C (2 x 160 hrs)
Final Electrical (Group A)	MIL-PRF-38534 & Specification	-55°C, +25°C, +85°C	-55°C, +25°C, +85°C
PDA	MIL-PRF-38534	N/A	2%
Seal, Fine and Gross	1014	Cond A	Cond A, C
Radiographic	2012	N/A	Yes
External Visual	2009	IR HiRel Defined	Yes

Notes:

① Any Engineering Model (EM) built with the "EM" Suffix shall only be form, fit and functional equivalent to its Flight Model (FM) counterpart, and it may not meet the radiation performance. The EM Model shall not be expected comply with MIL-PRF-38534 flight quality/workmanship standards, and configuration control. An EM build may use electrical equivalent commercial grade components. IR HiRel will provide a list of non-compliant items upon request.

② "No Suffix" designator indicates compliant items to class K screening as defined in the MIL-PRF-38534 but does not necessarily deem it to be a SMD part per MIL-PRF-38534.

Part Numbering



IOR HiRel
An Infineon Technologies Company
www.infineon.com/irhirel

101 N. Sepulveda Boulevard, El Segundo, California 90245, USA Tel: +1 (310) 252-7105
2520 Junction Avenue, San Jose, California 95134, USA Tel: +1 (408) 434-5000
205 Crawford Street, Leominster, Massachusetts 01453, USA Tel: +1 (978) 534-5776
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