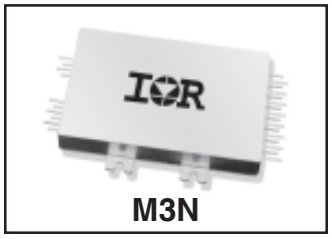
International
IOR Rectifier

PRELIMINARY

M3N-SERIES

100V Input, Triple Output

HYBRID - HIGH RELIABILITY RADIATION HARDENED DC-DC CONVERTER



M3N

Description

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 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 weighs less than 125 grams. The package utilizes 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 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 up to 64 MeV•cm^2/mg
- Low Input & Output Noise
- Low Weight, < 125 grams
- Magnetically Coupled Feedback
- 65V to 110V DC Input Range
- Up to 40W Output Power
- Triple Output Models Include +5V and ±12V or ±15V
- Main Output Isolated from Dual Outputs
- High Efficiency - to 82%
- -55°C to +125°C Operating Temperature Range
- 100MΩ @ 200VDC Isolation
- Under-Voltage Lockout
- Synchronization Input and Output
- Short Circuit and Overload Protection
- 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 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 reduces the conducted emissions to less than 5mA rms on the input power leads. A two-stage output filter reduces the typical output ripple to less than 20mV peak-to-peak.

The main (+5 volt) output is regulated by the control loop and typically exhibits better than 1% regulation. The auxiliary (±12 volt or ±15 volt) outputs are maintained through tight coupling in the power transformer and main output filter inductor and typically exhibit better than 5% regulation. The main output and auxiliary outputs are isolated from each other.

Output power is limited under any load fault condition to approximately 125% of maximum 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 60 volts. The two 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.

Design Methodology

The M3N-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 NASA EEE-INST-002 and MIL-STD-1547 except for the CDR type ceramic capacitors, a capacitor with 50V rating is used for in-circuit voltage stress of less than 10V. Careful sizing of decoupling capacitors and current limiting resistors minimizes the possibility of photo-current burn-out. 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).

Specifications

Absolute Maximum Ratings		Recommended Operating Conditions	
Input voltage range	-0.5Vdc to +120Vdc	Input voltage range [1]	+65Vdc to +110Vdc
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 derating per MIL-STD-975
[2] For operation at +125°C, see table note 15

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 Min	Limits Nom	Limits Max	Unit
Input Voltage	1,2,3	Note 2	65	100	110	V
Output voltage (V_{OUT}) (main) M3N1000512T (aux.) M3N1000515T (aux.) (main) M3N1000512T (aux.) M3N1000515T (aux.)	 1 2,3 	I_{OUT} = 100% rated load, Note 5	 4.98 ±11.50 ±14.60 4.93 ±11.30 ±14.40	 5.00 ±11.80 ±14.90	 5.02 ±12.10 ±15.20 5.07 ±12.30 ±15.40	V
Output power (P_{OUT})	1,2,3	V_{IN} = 65, 100, 110 Volts, Note 2	0		40	W
Output current (I_{OUT}) (main) M3N1000512T (aux.) M3N1000515T (aux.)	1,2,3	V_{IN} = 65, 100, 110 Volts, Notes 2, 3 ,4, 5	400 83 67		4000 ±833 ±667	mA
Line regulation (VR_{LINE}) (main) M3N1000512T (aux.) M3N1000515T (aux.)	1,2,3	V_{IN} = 65, 100, 110 Volts I_{OUT} =10%, 50%, 100% rated Notes 5, 14	 -10 -320 -350		 10 320 350	mV
Load regulation (VR_{LOAD}) (main) M3N1000512T (aux.) M3N1000515T (aux.)	1,2,3	I_{OUT} = 10%, 50%, 110% rated V_{IN} = 65, 100, 105 Volts Notes 5,13	 -50 -400 -500		 50 400 500	mV
Cross regulation (VR_{CROSS}) M3N1000512T (aux.) M3N1000515T (aux.)	1,2,3	V_{IN} = 65, 100, 110 Volts I_{OUT} = 2.5A to 1A and 2.5A to 4A on main and ±half rated on aux. outputs	 -3.5 -3.0		 3.5 3.0	%
Input current (I_{IN})	1,2,3	I_{OUT} = 0, Pin 3 open		35	50	mA
		Pin 3 shorted to pin 2		2.0	5.0	

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} = 100V DC ± 5%, C_L = 0 unless otherwise specified	Limits Min	Nom	Max	Unit
Output ripple (V_{RIP}) (main) M3N1000512T (aux) M3N1000515T (aux)	1,2,3	V_{IN} = 65, 100, 110 Volts I_{OUT} = 100% rated load, Notes 5, 6		25 30 30	50 60 75	mV p-p
Switching frequency (F_S)	1,2,3	Sync. Input (Pin 4) open	450	500	550	KHz
Efficiency (E_{FF})	1,2,3	I_{OUT} = 100% rated load, Note 5	78	82		%
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 0.5 80	KHz V V V/µs %
Current Limit Point Expressed as a percentage of full rated output power	1,2,3	V_{OUT} = 90% of Nominal, Note 5			135	%
Power dissipation, load fault (P_D)	1,2,3	Short Circuit, Overload, Note 8			18	W
Output response to step load changes (V_{TLD})	4,5,6	Half Load to/from Full Load, Notes 5 9	-300		300	mV pk
Recovery time, step load changes (T_{TLD})	4,5,6	Half Load to/from Full Load, Note 5, 9,10		50	200	µs
Output response to step line changes (V_{TLN})		65V to/from 110V I_{OUT} = 100% rated load, Notes1, 5,11	-300		300	mV pk
Recovery time, step line changes (T_{TLN})		65V to/from 110V I_{OUT} = 100% rated load, Notes 1. 5, 10,11		50	200	µs
Turn-on Response Overshoot (V_{OS}) (main) (aux.) Turn-on Delay (T_{DLY})	4,5,6	No Load, Full Load Notes 5,12	 1.0		 500 750 5.0	 mV mV ms
Capacitive Load (C_L) (main) (Each aux. output)		I_{OUT} = 100% rated load, No effect on DC performance, Notes 1, 5, 7			1000 200	µF
Line Rejection		DC to 50KHz, Notes 1, 5 I_{OUT} = 100% rated load	40	60		dB
Isolation	1,2,3	Input to Output or Any Pin to Case except pin 10, test @ 200VDC	100			MΩ
Device Weight					125	g
MTBF		MIL-HDBK-217F2, SF, 35°C	TBD			Hrs

For Notes to Specifications, refer to page 5

Notes: Electrical Performance Characteristics

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. Although operation with no load is permissible, light loading on the main (+5 volt) output may cause the output voltage of the auxiliary outputs (±12 volt or ±15 volt) to drop out of regulation. It is therefore recommended that at least 200 mA or 20 percent of the total output power, whichever Is greater, be taken from the main (+5 volt) output.
4. Although operation with no load is permissible, heavy loading on the main (+5 volt) output may cause the output voltage of the auxiliary outputs (±12 volt or ±15 volt) to rise out of regulation. It is therefore recommended that at least 50 mA or 20 percent of the total output power, whichever is greater, be taken from the auxiliary (±12 volt or ±15 volt) outputs.
5. Unless otherwise specified, "Rated" load is 20W on the main (+5 volt) output and 10 watts each on the auxiliary (±12 volt or ±15 volt) outputs. Load currents of up to 5A and ±1A on the main and auxiliary outputs respectively are acceptable as long as the total output power does not to exceed 40 watts.
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 $\geq$ 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 $\geq$ 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. Load Regulation relative to output voltage at 50% rated load.
14. Line Regulation relative to output voltage at 100Vdc input.
15. Although operation at temperatures between +85°C and +125°C is guaranteed, no parametric limits are specified.

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} = 28V	100		450	kRads(Si)
Single Event Effects SEU, SEL, SEGR, SEB ①	Heavy ions (LET) Operating bias applied during exposure Full Rated Load, V_{IN} = 28V 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.

Figure 1. Block Diagram - Triple Output

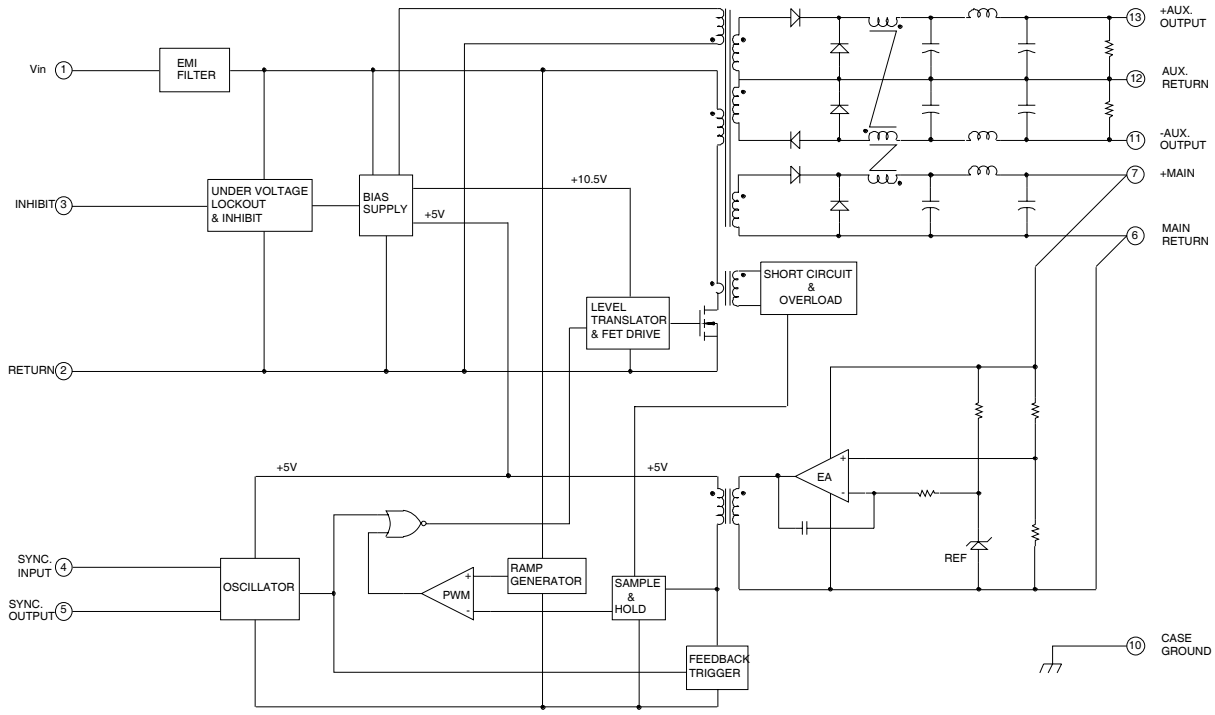


Figure 2. ±12V Load Regulation vs 5V Load

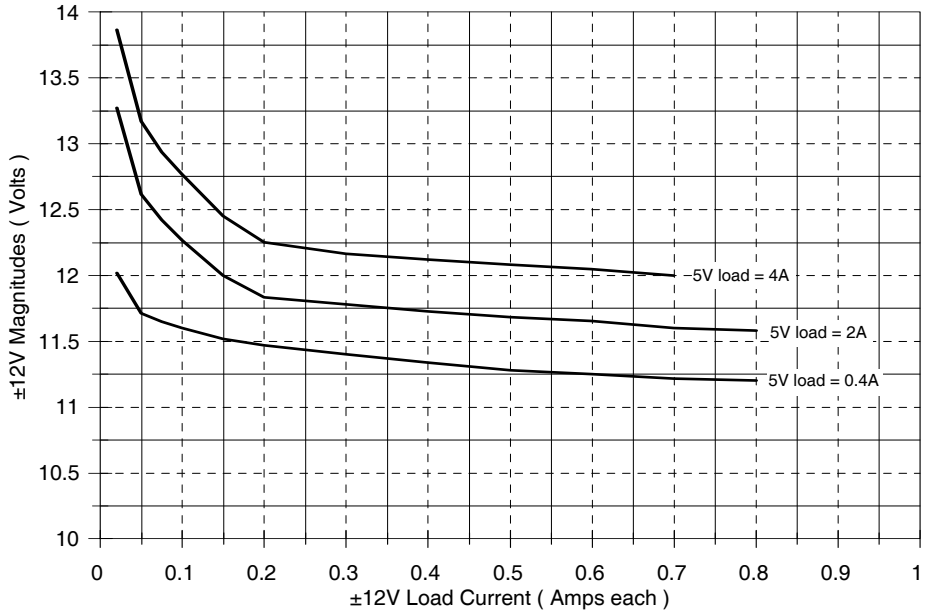
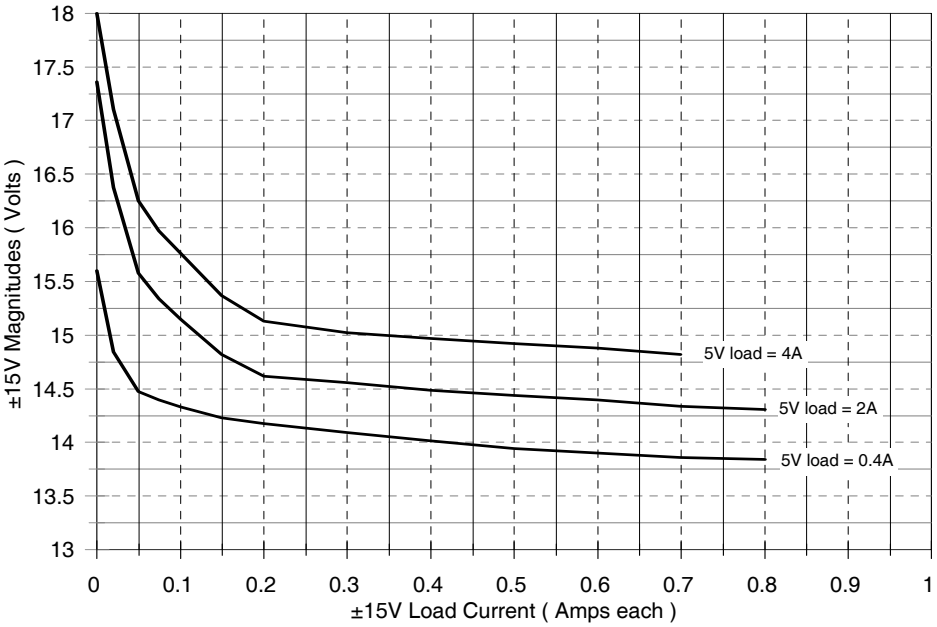
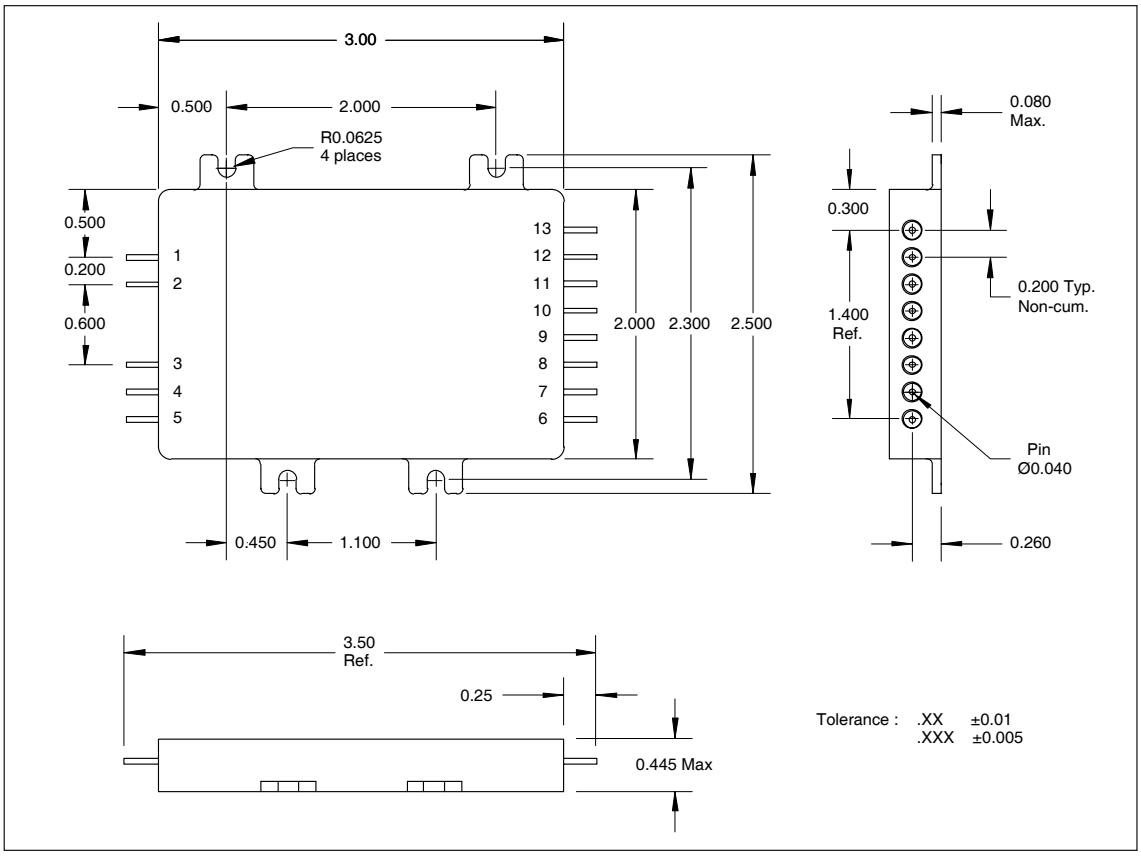


Figure 3. ±15V Load Regulation vs 5V Load



Mechanical Diagram



Pin Designation (Triple Output)

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

Device Screening

Requirement	MIL-STD-883 Method	B	No Suffix	EM
Temperature Range	—	-55°C to +85°C	-55°C to +85°C	-55°C to +85°C
Element Evaluation	MIL-PRF-38534	Class H	Class K	N/A
Non-Destructive Bond Pull	2023	Yes	Yes	N/A
Internal Visual	2017	Yes	Yes	①
Temperature Cycle	1010	Cond C	Cond C	Cond C
Constant Acceleration	2001, Y1 Axis	3000 Gs	3000 Gs	3000 Gs
PIND	2020	N/A	Cond A	N/A
Burn-In	1015	160 hrs @ 125°C	320 hrs @ 125°C (2 x 160 hrs)	48 hrs @ 125°C
Final Electrical (Group A)	MIL-PRF-38534 & Specification	-55°C, +25°C, +85°C	-55°C, +25°C, +85°C	-55°C, +25°C, +85°C
PDA	MIL-PRF-38534	10%	2%	N/A
Seal, Fine and Gross	1014	Cond A, C	Cond A, C	Cond A
Radiographic	2012	N/A	Yes	N/A
External Visual	2009	Yes	Yes	①

Notes:

① Best commercial practice.

Part Numbering

M3N 100 05 15 T /XX X

Model

Nominal Input Voltage
100 = 100V

Main Output Voltage
05 = +5V

Auxiliary Output Voltage
12 = ± 12V
15 = ± 15V

Output
T = Triple

Lead Finish
C = Gold Plated
A = Solder Dipped
Blank for No Suffix and EM
Lead Finish for No Suffix = Gold Plated
Lead Finish for EM is Gold Plated or Solder Dipped depending on availability

Screening Level
(Please refer to Screening Table)
EM = Engineering Model (form fit and functional equivalent, radiation performance is not guaranteed)
No Suffix = Flight Quality Class K equivalent screening
B = Flight Quality Class H equivalent screening.

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