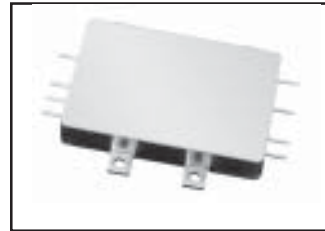


**ADVANCED ANALOG
HIGH RELIABILITY RADIATION
TOLERANT DC/DC CONVERTERS**

L-SERIES

+ 28V Input, Single/Dual Output



Description

The L-Series of DC/DC converters are radiation tolerant, high reliability devices designed for moderate radiation environments such as those encountered by low earth orbit satellites and launch vehicles. For higher radiation environments, the G-Series of DC/DC converters is recommended. Features include small size, low weight and 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 and MIL-STD-1547 and GSFC PPL-21 Appendix B. Extensive documentation including Radiation Susceptibility, Thermal Analysis, Stress Analysis and MTBF are available.

The converters incorporate a fixed frequency single forward topology with magnetic feedback and an internal EMI filter. These converters are capable of meeting the conducted emissions and conducted susceptibility requirements of MIL-STD-461C without any additional components. All models include an external inhibit port and have an adjustable output voltage. They are enclosed in a hermetic 1.5" x 2.3" x 0.425" steel package and weigh less than 85 grams. The package utilizes rugged ceramic feed-through copper core pins and is sealed using parallel seam welding.

Full environmental screening includes temperature cycling, constant acceleration, fine and gross leak, and burn-in.

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

Features

- Total Dose > 25K Rad(Si)
- SEE > 37 MeV.cm²/mg
- Internal EMI filter; Converter Capable of meeting MIL-STD-461C CE03 and CS01
- Low Weight, < 85 grams
- Magnetically Coupled Feedback
- 16V to 50V DC Input Range
- Up to 25W 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
- Adjustable Output Voltage
- External Inhibit
- 1,500,000 Hour MTBF

Applications

- Low Earth Orbit Satellites (LEO)
- Launch Vehicles

Circuit Description

The L-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 single-stage output filter reduces the typical output ripple to less than 50mV 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 external inhibit port is provided to control converter operation. The converter's operation is inhibited when this pin is pulled low. It is intended to be driven by an open collector logic device. The pin may be left open for normal operation and has a nominal open circuit voltage of 10.5V with respect to the input return (pin 2).

The output voltage of all models can be adjusted using a single external resistor.

Design Methodology

The L-Series was developed using a proven conservative design methodology which includes selecting radiation tolerance and established reliability components and fully derating to the requirements of MIL-STD-975 and MIL-STD-1547. Heavy derating of the power MOSFET gate and drain voltages minimize 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 Radiation Susceptibility (TREE), Stress, Thermal, and Reliability (MTBF).

Absolute Maximum Ratings

Input voltage range - -0.5Vdc to +60Vdc
 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 - 16Vdc to +60Vdc
 Input voltage range¹ - 16Vdc to +38Vdc
 Output power - 0 to Max. Rated
 Operating temperature² - -55°C to +125°C
 Operating temperature¹ - -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 (V _{OUT}) | | | | | | |
| M3L2803R3S | 1 | I _{OUT} = 100% rated load Note 4 | 3.27 | 3.30 | 3.33 | V |
| M3L2805S | 1 | | 4.95 | 5.00 | 5.05 | V |
| M3L2812S | 1 | | 11.88 | 12.00 | 12.12 | V |
| M3L2815S | 1 | | 14.85 | 15.00 | 15.15 | V |
| M3L2805D | 1 | | ±4.95 | ±5.00 | ±5.05 | V |
| M3L2812D | 1 | | ±11.88 | ±12.00 | ±12.12 | V |
| M3L2815D | 1 | | ±14.85 | ±15.00 | ±15.15 | V |
| M3L2803R3S | 2,3 | I _{OUT} = 100% rated load Note 4 | 3.23 | | 3.37 | V |
| M3L2805S | 2,3 | | 4.90 | | 5.10 | V |
| M3L2812S | 2,3 | | 11.76 | | 12.24 | V |
| M3L2815S | 2,3 | | 14.70 | | 15.30 | V |
| M3L2805D | 2,3 | | ±4.90 | | ±5.10 | V |
| M3L2812D | 2,3 | | ±11.76 | | ±12.24 | V |
| M3L2815D | 2,3 | | ±14.70 | | ±15.30 | V |
| Output power (P _{OUT}) | | | | | | |
| M3L2803R3S | 1,2,3 | V _{IN} = 16, 28, 50 Volts, Note 2 | 0 | | 20 | W |
| All Others | | | 0 | | 25 | W |
| Output current (I _{OUT}) | | | | | | |
| M3L2803R3S | 1,2,3 | V _{IN} = 16, 28, 50 Volts, Note 2 | 0 | | 6.06 | A |
| M3L2805S | | | 0 | | 5.00 | A |
| M3L2812S | | | 0 | | 2.08 | A |
| M3L2815S | | | 0 | | 1.67 | A |
| M3L2805D | | Either Output, Note 3 | 0 | | 4.00 | A |
| M3L2812D | | Either Output, Note 3 | 0 | | 1.67 | A |
| M3L2815D | | Either Output, Note 3 | 0 | | 1.33 | A |
| Line regulation (V _R LINE) | 1,2,3 | V _{IN} = 16, 28, 50 Volts I _{OUT} = 0, 50%, 100% rated, Note 4 | -0.5 | | 0.5 | % |
| Load regulation (V _R LOAD) | 1,2,3 | I _{OUT} = 0, 50%, 100% rated, Note 4 V _{IN} = 16, 28, 50 Volts | -1.0 | | 1.0 | % |
| Cross regulation (V _R CROSS) | | | | | | |
| M3L2805D | 1,2,3 | V _{IN} = 16, 28, 50 Volts | -5.0 | | 5.0 | % |
| M3L2812D | | Duals only, Note 5 | -3.0 | | 3.0 | % |
| M3L2815D | | | -3.0 | | 3.0 | % |

For Notes to Specifications, refer to page 5

L-SERIES

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, no load (I _{IN}) M3L2803R3S M3L2805S M3L2812S M3L2815S M3L2805D M3L2812D M3L2815D | 1,2,3 | I _{OUT} = 0, Pin 4 open | | | 60 70 70 70 70 100 100 | mA mA mA mA mA mA mA |
| Input current inhibited | 1,2,3 | Pin 4 shorted to pin 2 | | | 8 | mA |
| Output ripple (V _{RIP}) M3L2803R3S M3L2805S M3L2812S M3L2815S M3L2805D M3L2812D M3L2815D | 1,2,3 | V _{IN} = 16, 28, 50 Volts I _{OUT} = 100% rated load Notes 4, 6 | | | 35 50 70 80 80 80 80 | mV p-p mV p-p mV p-p mV p-p mV p-p mV p-p mV p-p |
| Switching frequency (F _S) | 1,2,3 | Sync. Input (Pin 4) open | 425 | 500 | 575 | KHz |
| Efficiency (E _{FF}) M3L2803R3S M3L2805S M3L2812S M3L2815S M3L2805D M3L2812D M3L2815D | 1,2,3 | I _{OUT} = 100% rated load Note 4 | 68 75 75 75 75 75 75 | 75 79 80 81 79 79 80 | | % % % % % % % |
| Enable Input (Inhibit Function) open circuit voltage drive current (sink) voltage range | 1,2,3 | Note 1 | 9.5 -0.5 | | 11.5 500 50 | V μA V |
| Current Limit Point Expressed as a percentage of full rated load current | 1,2,3 | V _{OUT} = 90% of Nominal, Note 4 | 105 | | 130 | % |
| Power dissipation, load fault (P _D) | 1,2,3 | Short Circuit, Overload, Note 8 | | | 14 | 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 | | | 200 | μS |
| Output response to step line changes (V _{TLN}) | 4,5,6 | 16V 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 | 16V to/from 50V I _{OUT} = 100% rated load, Notes 1,4,10,11 | | | 200 | μS |
| Turn-on Response Overshoot (V _{OS}) Turn-on Delay (T _{DLY}) | 4,5,6 | No Load, Full Load Notes 4,12 | 2 | | 500 10 | mV 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 |
|--|------------------|---|-----------------------|----|---|--|
| | | | | | | |
| Capacitive Load (CL) M3L2803R3S M3L2805S M3L2812S M3L2815S M3L2805D M3L2812D M3L2815D | 1 | 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 μF μF μF μF μF μF |
| Line Rejection | 1 | 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 3, test @ 500VDC | 100 | | | MΩ |
| Device Weight | | | | | 85 | grams |
| MTBF | | MIL-HDBK-217F2, SF, 35°C | 1.5 x 10 ⁶ | | | Hours |

Table I. Electrical Performance Characteristics - notes

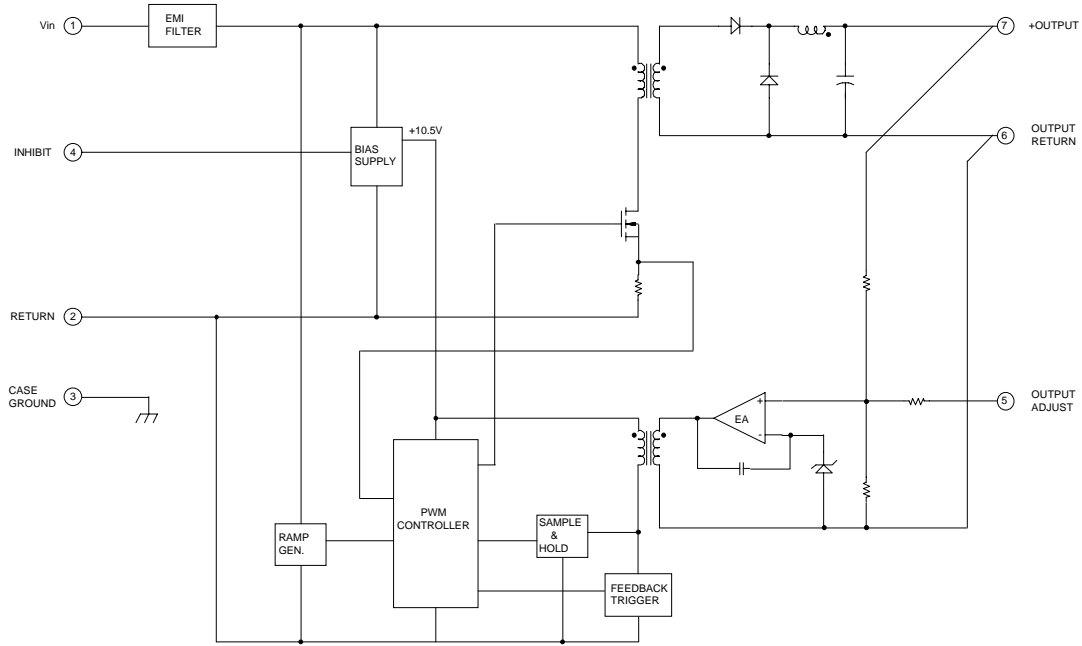
- 1) Parameter is tested as part of design characterization or after design changes. Thereafter, parameter shall be guaranteed to the limits specified.
- 2) Parameter verified during line and load regulation tests.
- 3) Output load current must be distributed such that at least 20% of the total load current is being provided by one of the 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 using the circuit shown below.
- 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 4) to the point where V_{OUT} = 90% of nominal.
- 13) For operation at temperatures between +85°C and +125°C, derate the maximum output power linearly from 100% to 75%.

Radiation Performance Characteristics

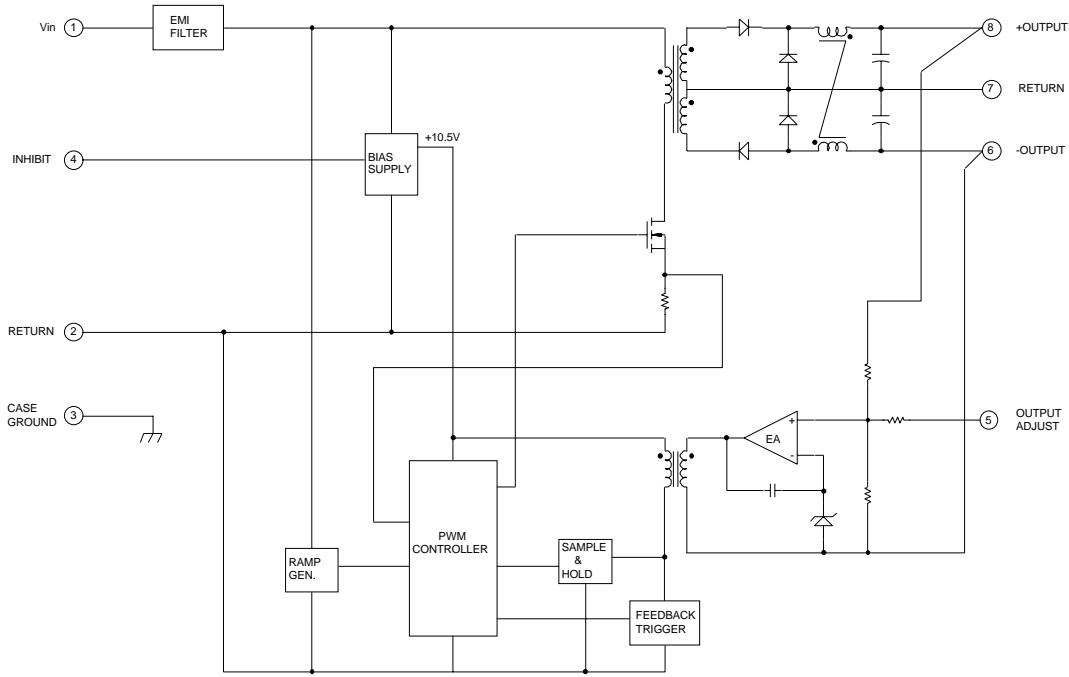
| Test | Conditions | Min | Typ | Highest Level Tested | Unit |
|---|--|-------------|-----|----------------------|------------------------------|
| Total Ionizing Dose (Gamma) | MIL-STD-883, Method 1019 Operating bias applied during exposure, Full Rated Load, $V_{IN} = 28V$ | 25 | 40 | 60 | KRads (Si) |
| Single Event Effects SEU, SEL, SEGR, SEB | Heavy ions (LET) Operating bias applied during exposure, Full Rated Load, $V_{IN} = 28V$ | 37 | 82 | 82 | MeV•cm ² /mg |
| Dose Rate (Gamma Dot) Temporary Saturation Survival | MIL-STD-883, Method 1023 Operating bias applied during exposure, Full Rated Load, $V_{IN} = 28V$ | 1E8 1E10 | | 1.5E9 | Rads (Si)/sec |
| Neutron Fluence | MIL-STD-883, Method 1017 | 3E12 | | 8E12 | Neutrons /cm ² |
| Proton Fluence | E > 10MeV | TBD | | N/A | protons /cm ² |

Device Screening

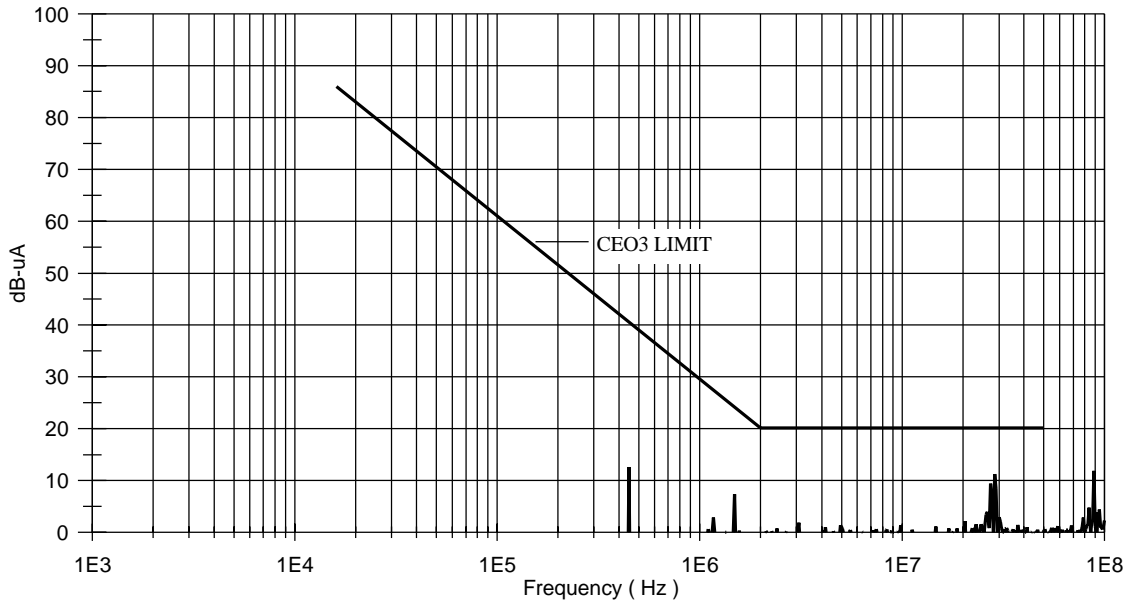
| Test Inspection | Method | Condition |
|---------------------------------|--|-----------------|
| Element Evaluation | MIL-PRF-38534 class H equivalent with SEM | |
| Nondestructive Bond Pull | MIL-STD-883, Method 2023 | |
| Internal Visual | MIL-STD-883, Method 2017 | |
| Temperature Cycling | MIL-STD-883, Method 1010 | C |
| Constant Acceleration | MIL-STD-883, Method 2001 (2k-g) | A, Y1 axis only |
| Electrical | In accordance with device specification | |
| Burn-in | MIL-STD-883, Method 1015 | 160 Hours |
| Final Electrical (Group A) | In accordance with device specification | |
| Seal Fine Leak Gross Leak | MIL-STD-883, Method 1014 | A1 C |
| External Visual | MIL-STD-883, Method 2009 | |



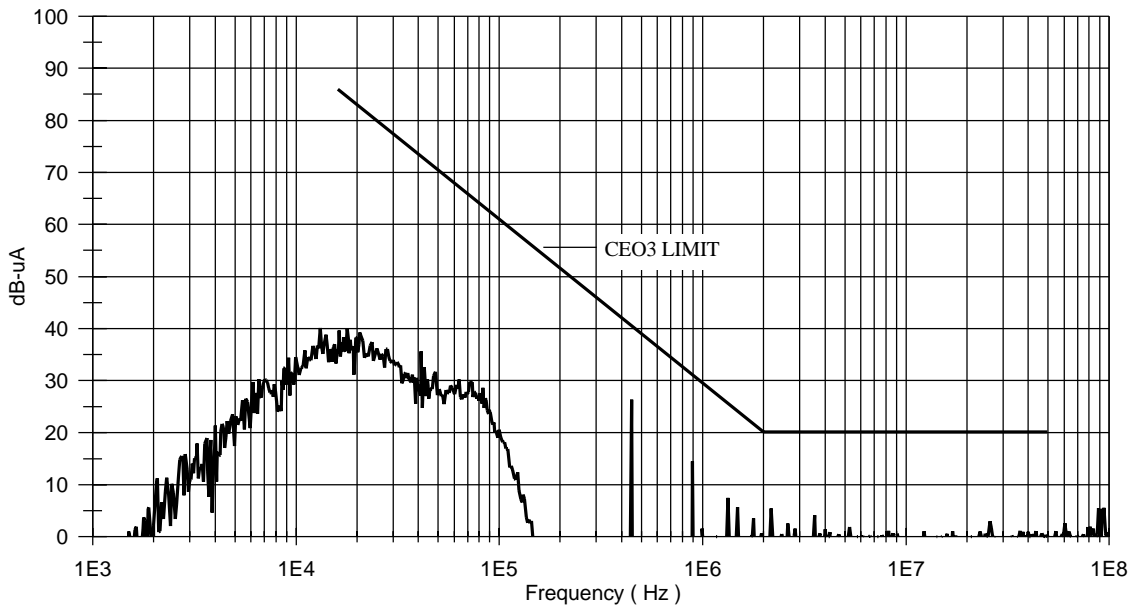
Block Diagram - Single Output



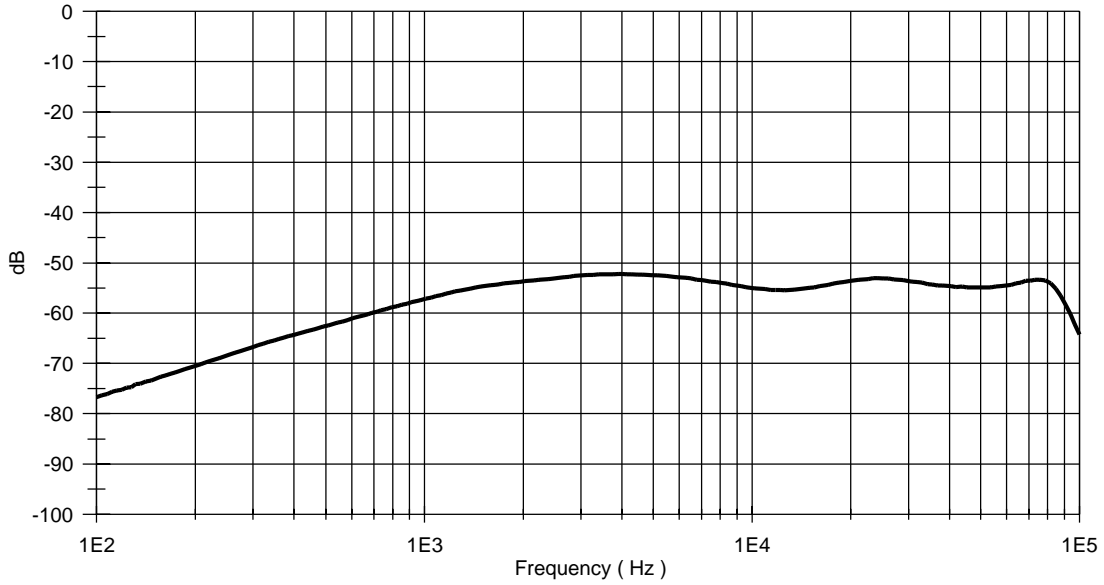
Block Diagram - Dual Output



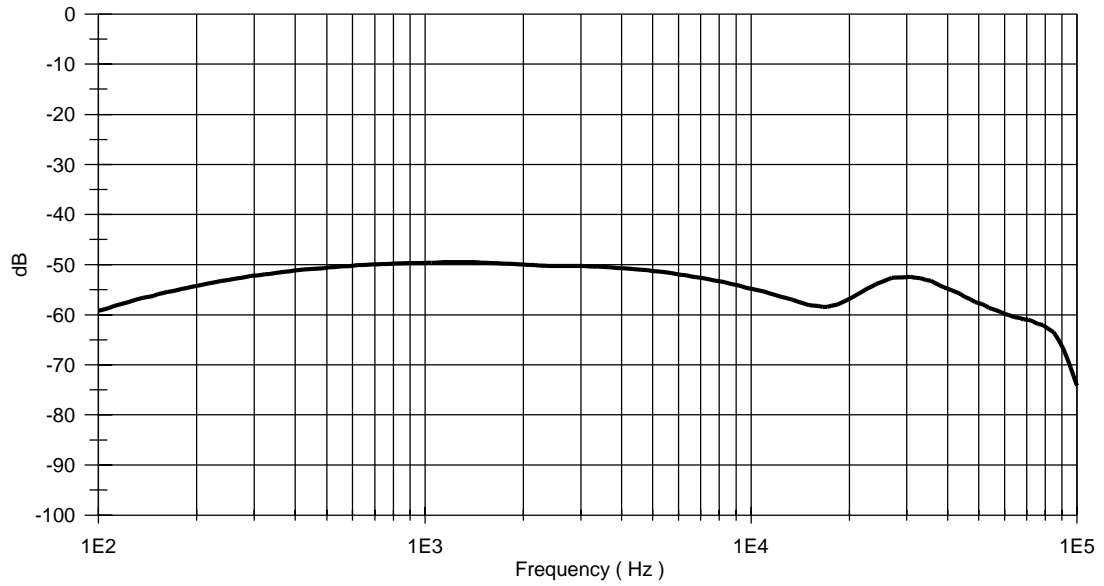
Conducted Emissions, Common Mode



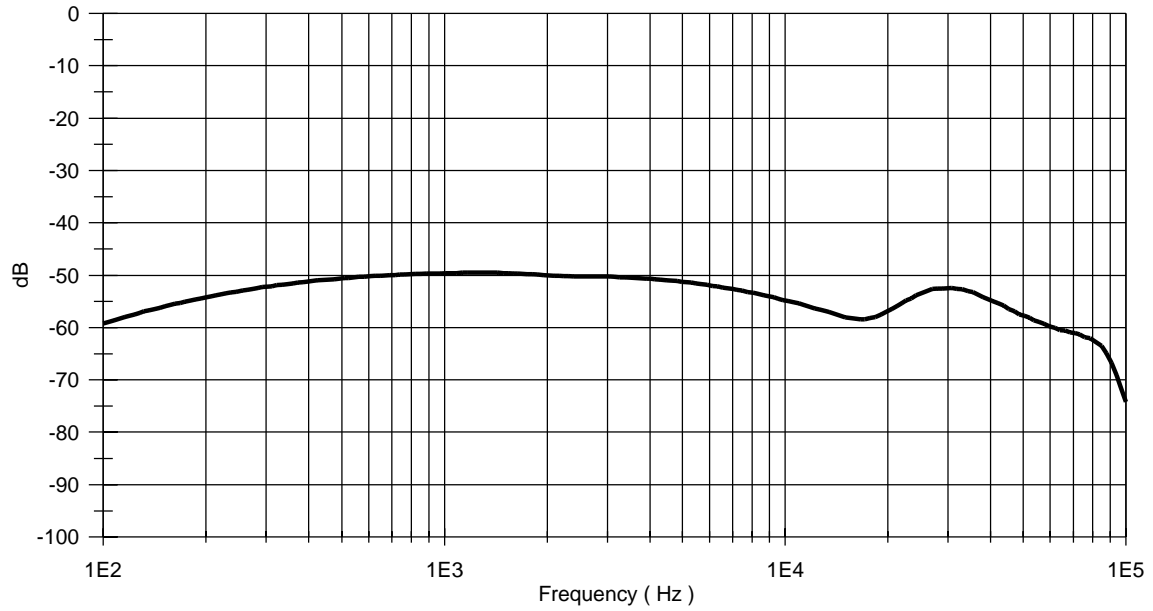
Conducted Emissions, Normal Mode



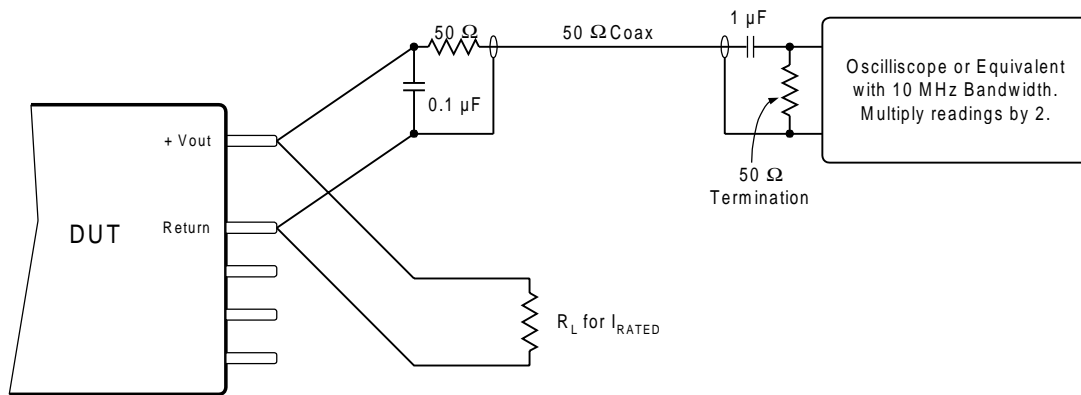
M3L2805S Line Rejection (CS01)



M3L2815D Line Rejection (CS01)

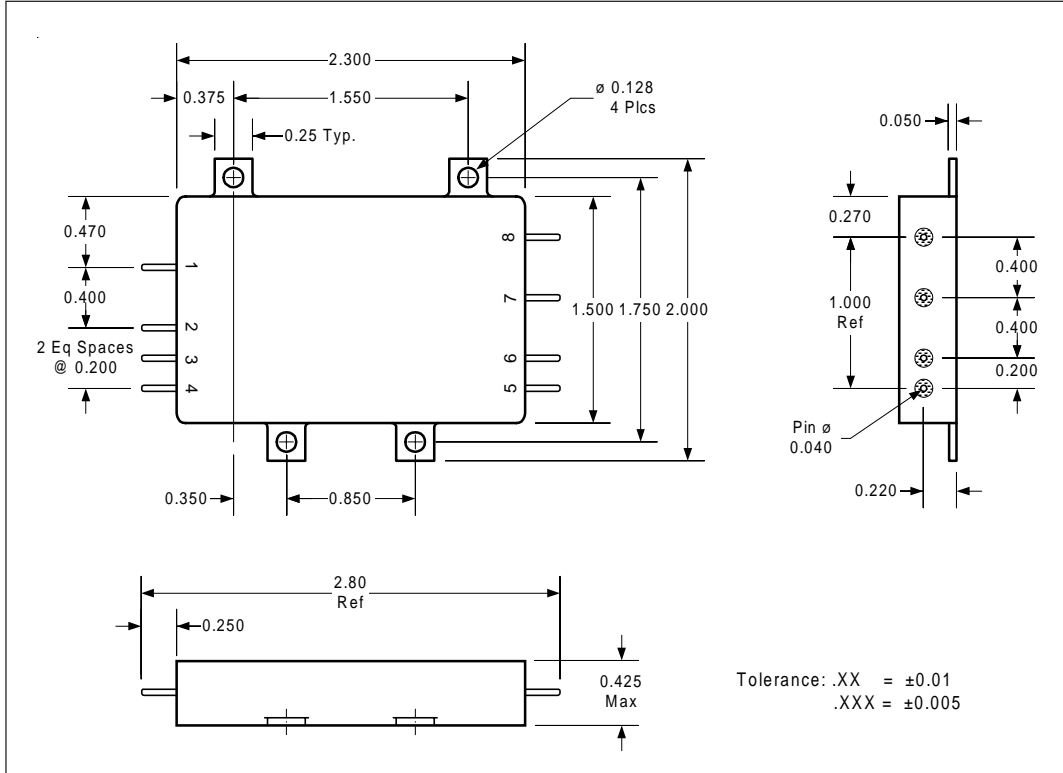


M3L2815D Line Rejections (CS01)



Circuit for Measuring Output Ripple Voltage

Mechanical Diagram

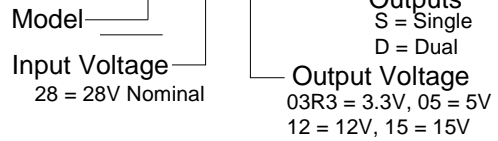


Pin Designation (Single/Dual)

| Pin Number | Single | Dual |
|------------|---------------|---------------|
| Pin 1 | + Input | + Input |
| Pin 2 | Input Return | Input Return |
| Pin 3 | Case | Case |
| Pin 4 | Inhibit | Inhibit |
| Pin 5 | Output Adjust | Output Adjust |
| Pin 6 | Output Return | - Vout |
| Pin 7 | + Vout | Output Common |
| Pin 8 | NC | + Vout |

Part Number

M3L 28 05 S



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