## Features & Benefits

- Isolated DC/DC Rugged Module
- EMI filter module is included
- Communication capability
- 91.3% Efficiency at Full Load
- Input UV/OV Lockout
- Input phase reversal protection
- Output OV/OC/SC Protection
- Thermal Shutdown
- Remote ON/OFF Control
- Output Voltage Remote Sense
- Output Voltage Trim Range +10%*, -40%

*: Trim-up capability input voltage range 18-40$V_{DC}$

## Compliance

Converter is designed to meet:

- MIL-STD-461G
- MIL-STD-810G
- MIL-STD-1275E

## Typical Applications

- Military/Defense Power Systems
- Armored Vehicles
- Land Platforms
- Aerospace Platforms
- Communications and Radar Systems

| **Product Ratings** | |
|---|---|
| $V_{IN}$ | 16–40 $V_{DC}$ |
| $V_{IN\_NOM}$ | 28 $V_{DC}$ |
| $V_{OUT}$ | 28 $V_{DC}$ |
| $I_{OUT\_MAX}$ | 10.7 $A_{DC}$ |
| $P_{OUT\_MAX}$ | 300 W |

## Product Description

KMRM01-DC28-P300-DC28-CM is a 300 W DC/DC converter in rugged module that operates from nominal 28 V input and generates 28 V isolated output. It is designed to meet MIL-STD-461G EMI requirements with the built-in KRFL01 EMI filter module and has superior noise and ripple performance. Converter is fully protected to operate reliably under all kinds of disturbances. Casing is creatively designed to provide efficient cooling to facilitate reliable operation up to 100 °C base plate temperature.

Size: 100 x 80 x 23.4 mm
[3.94” x 3.15” x 0.92”]

Weight: 340 g

## Signals and Functions

**+IN**: Input supply voltage positive line.

**-IN**: Input supply voltage return line.

**ON/OFF**: Remote on/off pin. Referenced to **-IN** input return line. Should be pulled to input return line to turn the converter on. Can be left open to turn off the converter.

**CHASSIS**: Chassis connection for cabling purposes.

**+OUT**: Output voltage positive line.

**-OUT**: Output voltage return line.

**+SNS**: Remote sense positive line. Could be used to regulate output voltage at load terminals. Should be connected to positive side of Load. Using sense function with an ORing circuit may cause unstable output voltages. It is recommended to not connect this pin while using an ORing circuit.

**-SNS**: Remote sense negative line. Could be used to regulate output voltage at load terminals. Should be connected to negative side of Load. Using sense function with an ORing circuit may cause unstable output voltages. It is recommended to not connect this pin while using an ORing circuit.

**TRIM**: Trim pin can be used to increase or decrease output voltage within specified limit via a resistor. Trim up and down equations are given in Basic Operation and Features section.

**PMBUS_SDA***: I2C communication data line. Internally pulled up to 3.3 Vdc via 10 kΩ resistor. Can be left open if not used. Referenced to output return line(-OUT).

**PMBUS_SCL***: I2C communication clock line. Internally pulled up to 3.3 Vdc via 10 kΩ resistor. Can be left open if not used. Referenced to output return line(-OUT).

**PMBUS_ADDRESS***: I2C communication address selection line. Can left open or connected to Output return line to choose I2C address of converter between 0x81 and 0x83 respectively. Referenced to output return line(-OUT).

**NC**: DO NOT CONNECT. Connecting these pins to any other terminal may damage the converter.

All pins with identical function and name should be connected together for best results.

*: Available on PMBUS option.

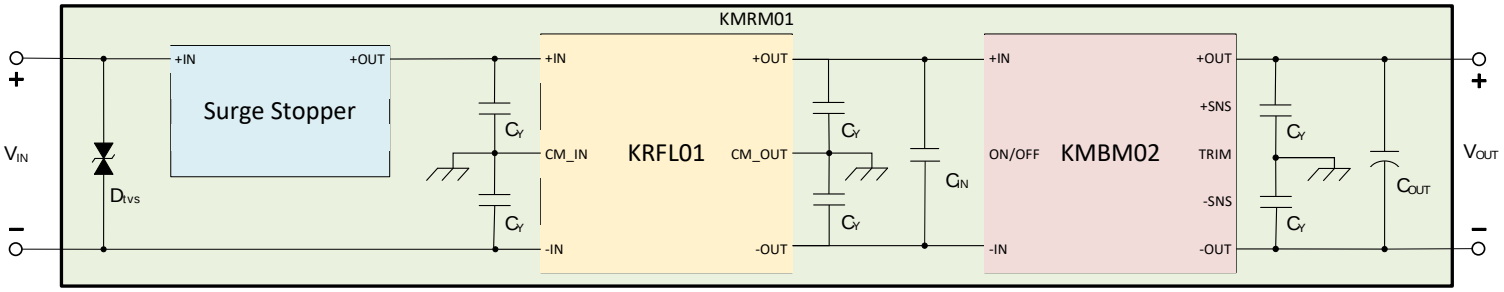



**Figure A.** KMRM01 internal block diagram

**KRFL01:** EMI Filter Module
**KMBM02:** Isolated DC/DC Converter Module
**CY**: CHV1206N2K0472KXT (4700 pF 2kV X7R Ceramic Capacitor)
**CIN**: CL32Y106KCVZNWE (22 x 10uF 100V Ceramic Capacitor)
**COUT**: A759KS476M1KAAE045 (2 x 47uF 80V Aluminum-Polymer Capacitor))
**DTVS**: 5.0SMDJ100CA (3 x Bi-directional 100Vwm TVS Diode)

## Electrical Characteristics

All data are obtained at nominal line and full load unless otherwise specified. (Ta = 25 °C)

| Input Characteristics | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Notes & Conditions** | **Min** | **Typ** | **Max** | **Unit** |
| **Non-Operating Input Voltage Range** | Continuous | -40 | | 60 | V |
| **Input Voltage Transient** | 50ms @ full load | | | 50 | V |
| **Operating Input Voltage Range** | | 16 | 28 | 40 | V |
| **Input Under Voltage Turn-On Threshold** | | 15.5 | 16 | 16.5 | V |
| **Input Under Voltage Turn-Off Threshold** | | 14.5 | 15 | 15.5 | V |
| **Input Over Voltage Turn-On Threshold** | | 36 | 36.5 | 37 | V |
| **Input Over Voltage Turn-Off Threshold** | | 40 | 40.5 | 41 | V |
| **No-Load Input Current** | | | 283 | 300 | mA |
| **Disabled Input Current** | | | 9.5 | 12 | mA |

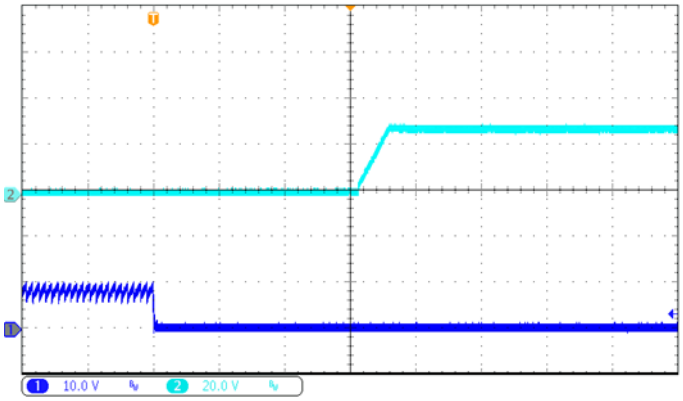
| Output Characteristics | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Notes & Conditions** | **Min** | **Typ** | **Max** | **Unit** |
| **Output Voltage** | | | 28 | | V |
| **Output Voltage Set Point** | | | | ± 1 | % |
| **Output Voltage Line Regulation** | | | | ± 0.2 | % |
| **Output Voltage Load Regulation** | | | | ± 0.2 | % |
| **Output Voltage Ripple and Noise** | 20 MHz bandwidth | | 350 | 400 | $mV_{PK-PK}$ |
| **Operating Output Current Range** | | 0 | | 10.7 | A |
| **Output Current Limit** | | | | 11 | A |
| **Output DC Current-Limit Shutdown Voltage** | | | 14 | | V |
| **Output Power** | | | 300 | | W |
| **Maximum Output Capacitance** | Nominal output voltage | | | 3 | mF |
| **Input Voltage Transient Response** | 50 V/ms; See Figure D | | | | |
| **Step Change** | 28V to 40V to 28V input voltage | | 0.5 | 1 | V |
| **Settling Time** | Within 1% output voltage | | 2 | | ms |
| **Load Current Transient Response** | 1 A/µs; See **Error! Reference source not found.**Figure F and Figure C | | | | |
| **Step Change** | 50% to 75% to 50% output load | | 0.8 | 1 | V |
| **Settling Time** | Within 1% output voltage | | 1 | | ms |
| **Output Voltage Trim Range** | Across Sense+ and Sense- Pins | -40 | | +10 | % |
| **Output Over-Voltage Protection** | | | | 33.6 | V |

| General Characteristics | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Notes & Conditions** | **Min** | **Typ** | **Max** | **Unit** |
| **Efficiency** | From half load to full load | 91 | | | % |
| **Turn-On Transient Time** | Within 90% output voltage | | 35 | | ms |
| **Turn-On Transient Output Voltage Overshoot** | Maximum output capacitance | | 1 | | % |
| **Soft-Start Time** | Within 90% output voltage | | 5 | | ms |
| **Switching Frequency** | | | 150 | | kHz |
| **Non-Operating ON/OFF Pin Voltage** | Continuous | -1 | | 60 | V |
| **ON/OFF Control On-State Voltage** | | -1 | | 10 | V |
| **ON/OFF Control Off-State Voltage** | | 16 | | 40 | V |
| **MTBF** | Ground Fixed, 40°C Ta | | 308 | | $10^3$ Hrs. |
| **Over Temperature Shutdown Trip Point** | | | 115 | | °C |
| **Over Temperature Shutdown Hysteresis** | | | 15 | | °C |

| Isolation Characteristics | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Notes & Conditions** | **Min** | **Typ** | **Max** | **Unit** |
| **Insulation Resistance** | $500V_{DC}$ | | | | |
| **Input to Base Plate** | | | >45 | | GΩ |
| **Output to Base Plate** | | | >45 | | GΩ |
| **Isolation Voltage** | 60s dwell, 1mA trip current | | | | |
| **Input to Output** | | | 2250 | | $V_{DC}$ |
| **Input to Base Plate** | | | 2250 | | $V_{DC}$ |
| **Output to Base Plate** | | | 2250 | | $V_{DC}$ |

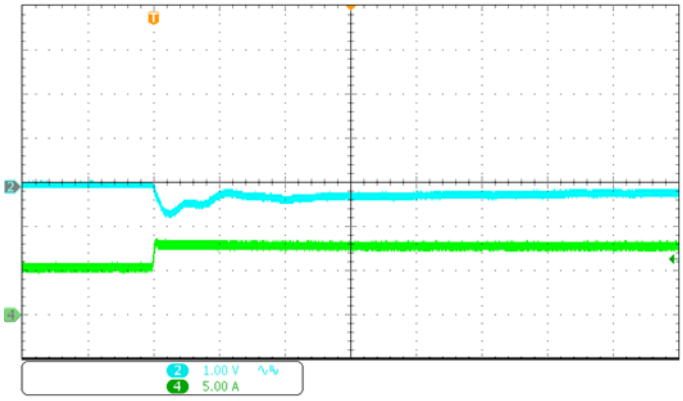
| Environmental Characteristics | | | | | | |
|---|---|---|---|---|---|---|
| **Parameters** | **Standard** | **Min** | **Typ** | **Max** | **Unit** | **Status** |
| **Operational Baseplate Temperature** | MIL-STD-810G_CHG-1 Method 501.6/502.6 Procedure II | -40 | - | +100 | °C | Passed* |
| **Storage / Transport Temperature** | MIL-STD-810G_CHG-1 Method 501.6/502.6 Procedure I | -55 | - | +125 | °C | Passed* |
| **Operational Low Pressure** | MIL-STD-810G_CHG-1 Method 500.6 Procedure II | - | - | 3000 | m | Passed* |
| **Storage / Transport Low Pressure** | MIL-STD-810G_CHG-1 Method 500.6 Procedure I | - | - | 9000 | m | Designed to Meet |
| **Parameters** | **Standard** | **Waveform** | **Peak Value** | **Pulse Duration** | **Axis** | **Status** |
| **Shock** | MIL-STD-810G_CHG-1 Method 516.7 Procedure I | Half-Sine | 10g | 11 ms | ±X, ±Y, ±Z | Passed* |
| **Parameters** | **Standard** | **Category** | **Figure** | **Platform** | **Vehicle** | **Status** |
| **Vibration** | MIL-STD-810G_CHG-1 Method 514.7 Procedure I | Category 4 | 514.7C-2 | Secured Cargo | Truck Transportation and Composite Wheeled Vehicles | Passed* |
| | | Category 8 | 514.7C-8 | Aircraft | Propeller | Passed* |
| | | Category 11 | 514.7C-11 | Railroad | Train | Passed* |
| | | Category 20 | 514.7C-4 | Ground | Wheeled Vehicles | Passed* |
| | | Category 21 | 514.7D-9 | Watercraft | Marine Vehicles | Passed* |
| **Parameters** | **Standard** | **Condition** | | | | **Status** |
| **Salt Fog** | MIL-STD-810G_CHG-1 Method 509.6 | 24 hours spray, 24 hours dry, applied 2 times | | | | Designed to Meet |
| **Sand and Dust** | MIL-STD-810G_CHG-1 Method 510.6 Procedure I/II | <150 µm Dust<br>150-850 µm Sand | | | | Designed to Meet |
| **Fungus** | MIL-STD-810G_CHG-1 Method 508.7 | Analysis of the degree of inertness to fungus growth of the components. | | | | Analysis |
| **Solar Radiation** | MIL-STD-810G_CHG-1 Method 505.6 Procedure I | A2 | | | | Passed* |
| **Humidity** | MIL-STD-810G_CHG-1 Method 507.6 Procedure II | ≥ %95 Relative @30°C | | | | Passed* |
| **Parameters** | **Standard** | **Test** | | | | **Status** |
| **EMI/EMC** | MIL-STD-461G Ground Army | CE102 | CS101<br>CS114<br>CS115<br>CS116<br>CS118 | RE102 | RS103 | Passed* |

* Verified in a multi-channel power supply.



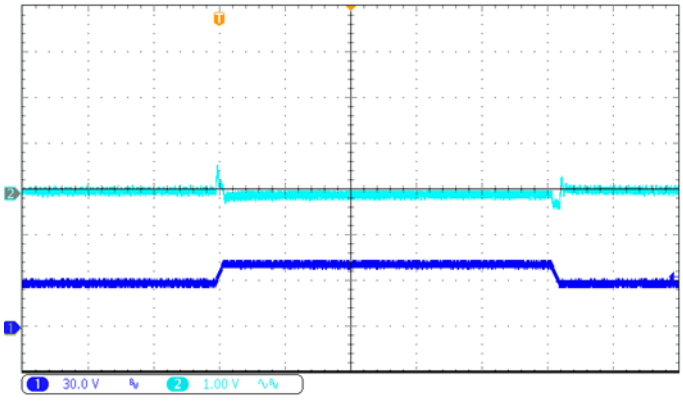

Output voltage (light blue) (20 V/div) Time base: 10 ms/div
ON/OFF pin voltage (blue) (10 V/div)

**Figure B.** Startup waveform, input voltage pre-applied with 1 µF ceramic capacitor across the load terminals



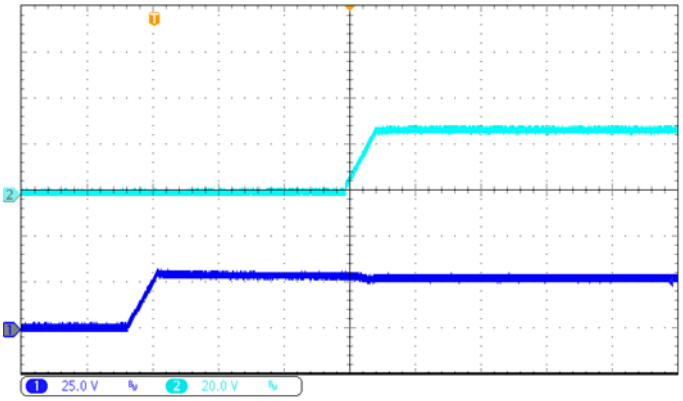

Output voltage (light blue) (1 V/div) Time base: 200 µs/div
Output current (green) (5 A/div)

**Figure C.** Load current transient response (AC Coupled): from 50% to 75% with 1 µF ceramic capacitor across the load terminals (di/dt = 1 A/µs)



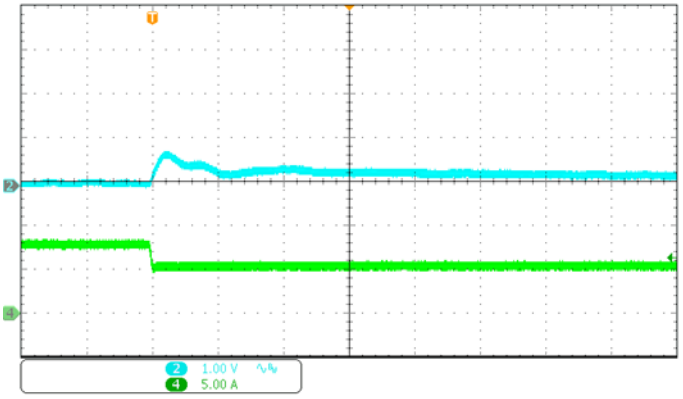

Output voltage (light blue ) (1 V/div) Time base: 10 ms/div
Input voltage (blue) (30 V/div)

**Figure D.** Input voltage transient response (AC Coupled): from 28 V to 40 V and 40 V to 28 V with 1 µF ceramic capacitors across the load terminals. (dV/dt = 50 V/ms)



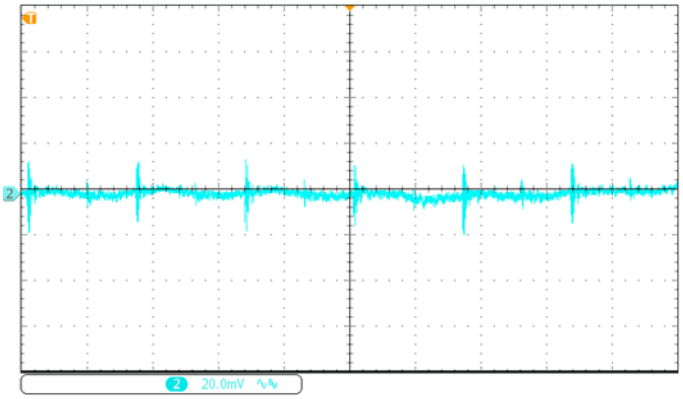

Output voltage (light blue) (10 V/div) Time base: 10 ms/div
Input voltage (blue) (25 V/div)

**Figure E.** Turn on transient at full resistive load with 1 µF ceramic capacitor across the load terminals




Output voltage (light blue) (1 V/div) Time base: 200 µs/div
Output current (green) (5 A/div)

**Figure F.** Load current transient response (AC Coupled): from 75% to %50 with 1 µF capacitor across the load terminals. (di/dt = 1 A/µs)




Output voltage ripple (200 mV/div) Time base: 2 µs/div

**Figure G.** Output voltage ripple at nominal input voltage and full load current with 1 µF ceramic capacitor across the load terminals (Bandwidth: 20 MHz)

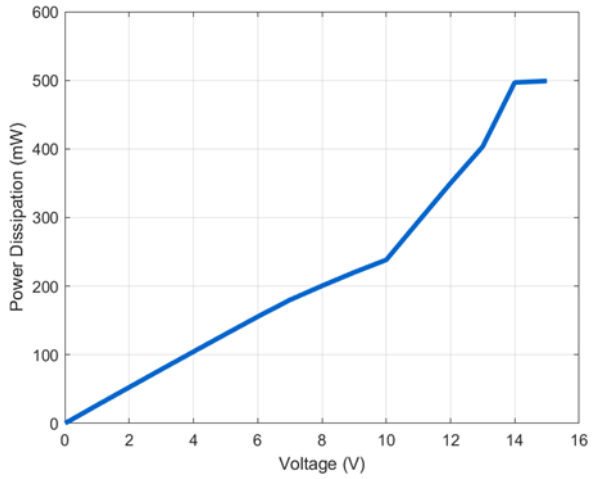



**Figure H.** Disabled power dissipation versus input voltage

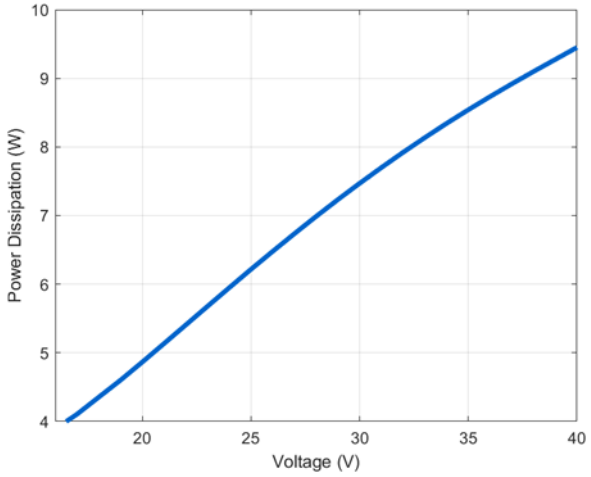



**Figure K.** Enabled power dissipation versus input voltage

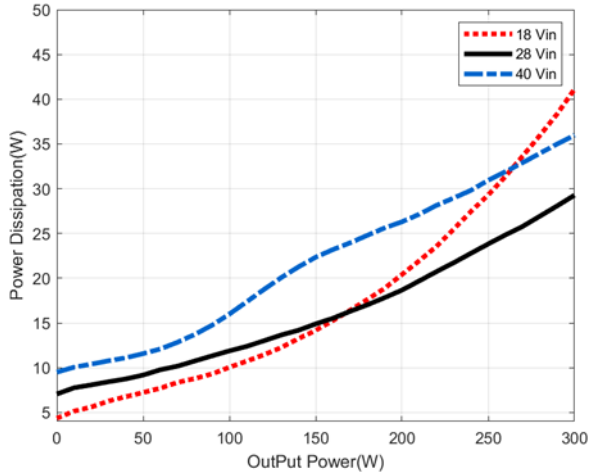



**Figure I.** Power dissipation versus output power at minimum, nominal and maximum input voltage at nominal output voltage

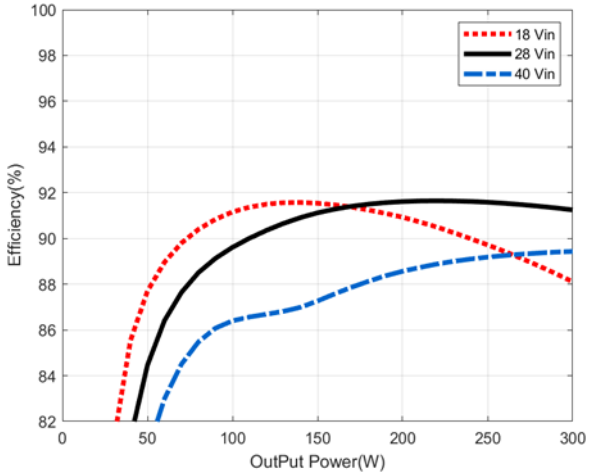



**Figure L.** Efficiency versus output power at minimum, nominal and maximum input voltage at nominal output voltage

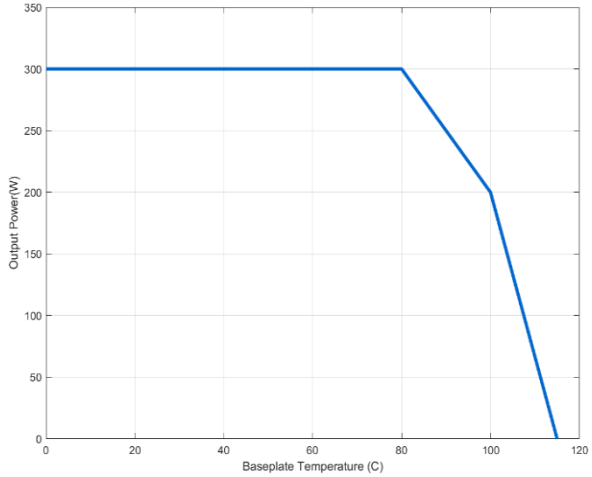



**Figure J.** Thermal Derating (maximum output power vs baseplate temperature) at nominal input voltage

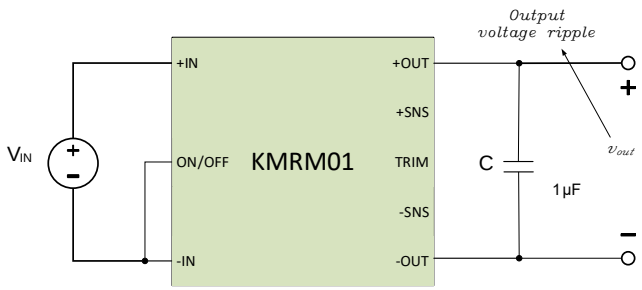



**Figure M.** Test set-up showing measurement point for output voltage ripple (**Figure G**).

# Basic Operation and Features

## REMOTE ON/OFF

The ON/OFF input, Pin 23, allows the user to control the ON and OFF states of the module. This input, which is referenced to the return terminal of the input bus (-IN), is hold as active low to keep the module at ON state. If it is pulled down to the return terminal of the input bus (-IN), converter goes into ON state. Moreover, the ON/OFF function allows the product to be turned on/off by an external device like a semiconductor or a mechanical switch.

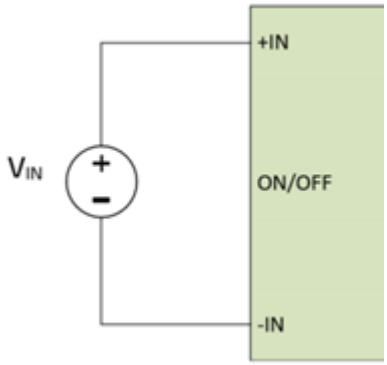



**Figure N.** Recommended OFF State Connection

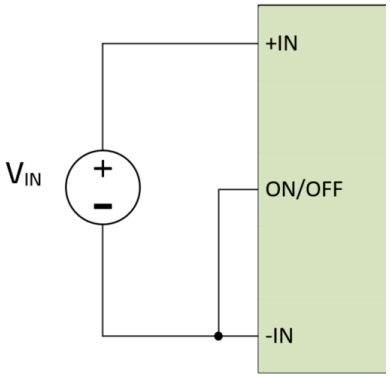



**Figure O.** Recommended ON State Connection

## SENSE

Sense terminals are placed at the load side of the converter module. The sense inputs are used to adjust and fine tune the output voltage and compensate for any error at the voltage level. If the load is away from the unit, which may require connection over a long pair of cable, connect +SNS and -SNS to the terminal of the load respectively to compensate for the voltage drop across the line.

## OUTPUT VOLTAGE TRIM

TRIM input feature of the module permits the user to adjust the output voltage across the sense leads up or down according to the trim range. To decrease the output voltage, the user should connect a resistor between TRIM and +SNS input.

For a desired decrease of the nominal output voltage, the value of the resistor should be calculated as below.

$$R_{TRIM\_DOWN} = 9.18 * \frac{(V_{OUT_{nom}} - V_{OUT_{desired}} * 1.99)}{(V_{OUT_{desired}} - V_{OUT_{nom}})}\ k\Omega$$

Output Voltage resulting from trim down resistor can be calculated as below. $R_{TRIM\_DOWN}$ is trim down resistor's value in kΩ.

$$V_{Generated} = V_{OUT_{nom}} * \frac{(9.18 + R_{TRIM\_DOWN})}{(R_{TRIM_{DOWN}} + 18.27)}\ V$$

To increase the output voltage, the user should connect a resistor between TRIM and -SNS input. For input voltages below 18 V at full-load, converter is not able to regulate output voltage above 28 V. So, for lower than 18 V input voltages, trim-up capability is limited.

Converter is able to regulate output voltage to 28 V at full load, starting from 16 V input voltage.

For a desired increase of the nominal output voltage, the value of the resistor should be calculated as below.

$$R_{TRIM\_UP} = \frac{(9.18 * V_{OUT_{nom}} - V_{OUT_{desired}} * 8.25)}{(V_{OUT_{desired}} - V_{OUT_{nom}})}\ k\Omega$$

Output Voltage resulting from trim up resistor can be calculated as below. $R_{TRIM\_UP}$ is trim up resistor's value in kΩ.

$$V_{Generated} = V_{OUT_{nom}} * \frac{(9.18 + R_{TRIM\_UP})}{(R_{TRIM_{UP}} + 8.25)}\ V$$

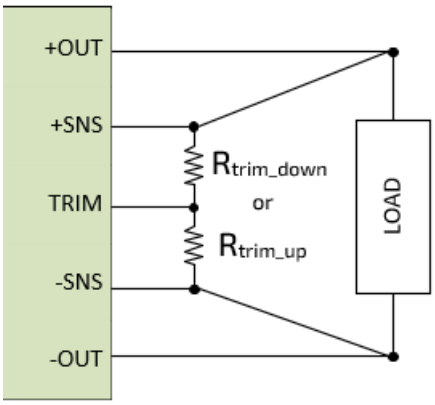



**Figure P.** Typical Trim Application Circuit

### DROOP CURRENT SHARING

For “droop active” models (part numbers with PR option), output voltage has a 1 V slope from full load to no load. In other words, output voltage of the module is 28.5 V for no load and 27.5 V for full load. This enables safe parallel connection of multiple models.

For connection diagram, please refer to Figure T. Recommended Application N+1 Redundant Parallel Connection Figure T. ORing diodes (simple diode or ideal diode) are required for parallel connection.

### PMBUS

This module offers a PMBUS digital interface that enables the user to monitor input voltage, output voltage, output current, and device temperature. The PMBUS interface uses the two-wire I2C standard during communication.

Please refer to 105847 KMBM02 I2C Communication Manual for detailed information on PMBUS capability.

## Protection Features

### Reverse Input Protection

Converter module stays unharmed even if it is subjected to reverse input voltages. The associated limits are given in “Module Input Specifications” Table.

### Input Over Voltage Protection

Converter module protects itself by ceasing operation when input goes above “Over Voltage Turn-Off Threshold ”. It resumes operation when input falls below “Over Voltage Turn-On Threshold ”. The associated limits are given in “Module Input Specifications” Table.

### Output Current Limit

If the output current exceeds the “Output Current Limit” value, the converter will immediately stop operating. The control waits for 500 ms and resets the fault status automatically and resumes operation with soft start. If the fault condition is still persisting, its shuts off again. This sequence is repeated indefinitely.

### Output Over Voltage Protection

The default output OVP limit is set to 20% above the nominal output voltage. When detected, protection control responds immediately by shutting down the converter and disabling the outputs. Start sequence is similar to the output current limit case.

### Short Circuit Protection

The short circuit condition is an extreme case of the Output Current Limit condition. When the fast rise of the current during a short circuit condition is detected by the dedicated controller, the outputs of the converter are disabled immediately. The sequence of operation after a short circuit detection is similar to hiccup concept described in “Output Current Limit” section.

### Over Temperature Shutdown

The brick has a thermistor located at the hottest point inside the module. The thermal shutdown circuit is designed to turn the converter off when the temperature at the sensed location goes above the “Over Temperature Shutdown” limit. It locks itself and waits to cool off. Converter then resumes operation automatically when the temperature of the sensed location falls below the trip point by the amount equal to the “Over Temperature Shutdown Hysteresis”

## MIL-STD-461E CE102 Test Results

Following EMI measurements have been performed in KOLT's EMI test laboratory using Rohde&Schwarz FPC1000 Spectrum Analyzer. KMRM01 loaded to supply 300 W to a resistive load at nominal input and output voltage. No external EMI filter is needed.

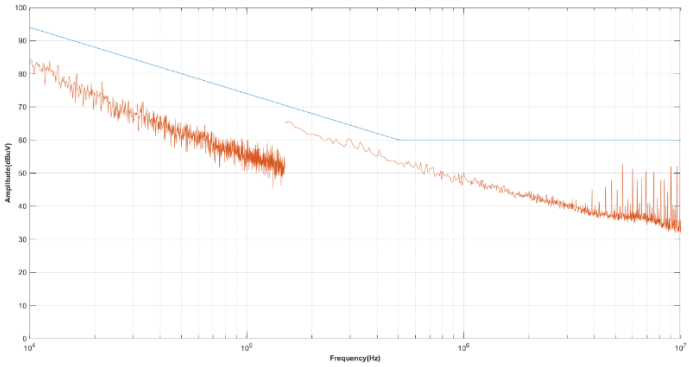


**Figure Q.** MIL-STD-461G CE102 Positive Line

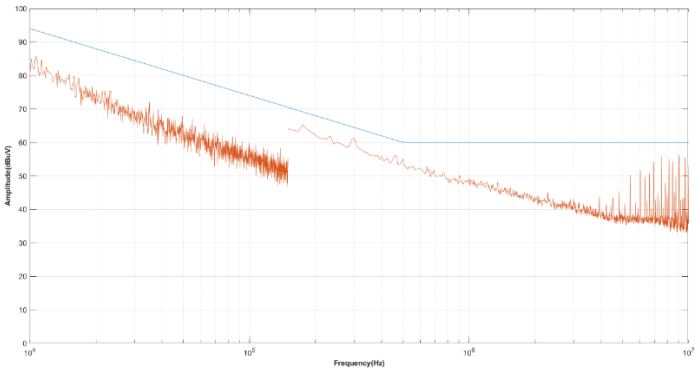


**Figure R.**MIL-STD-461E CE102 Negative Line

## Application Considerations

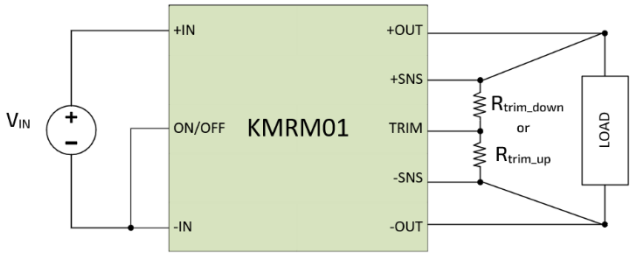



**Figure S.** Typical Application

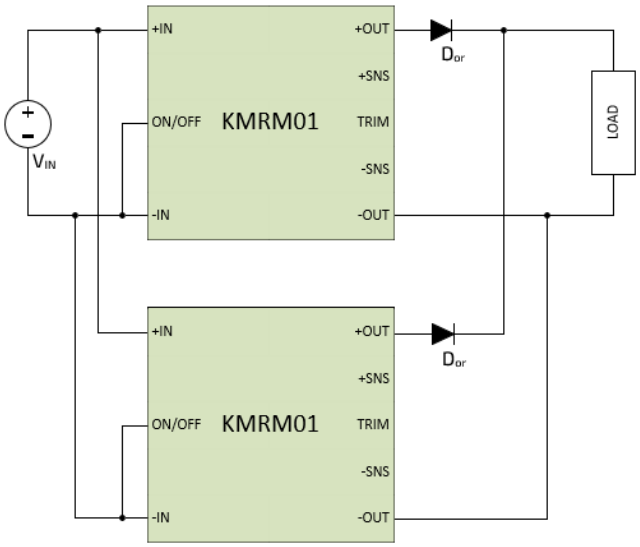



**Figure T.** Recommended Application N+1 Redundant Parallel Connection

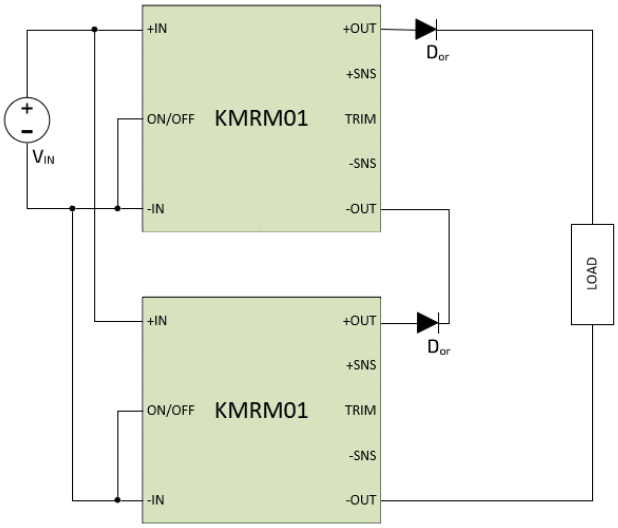
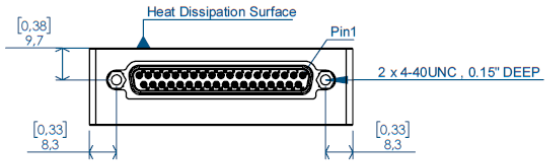
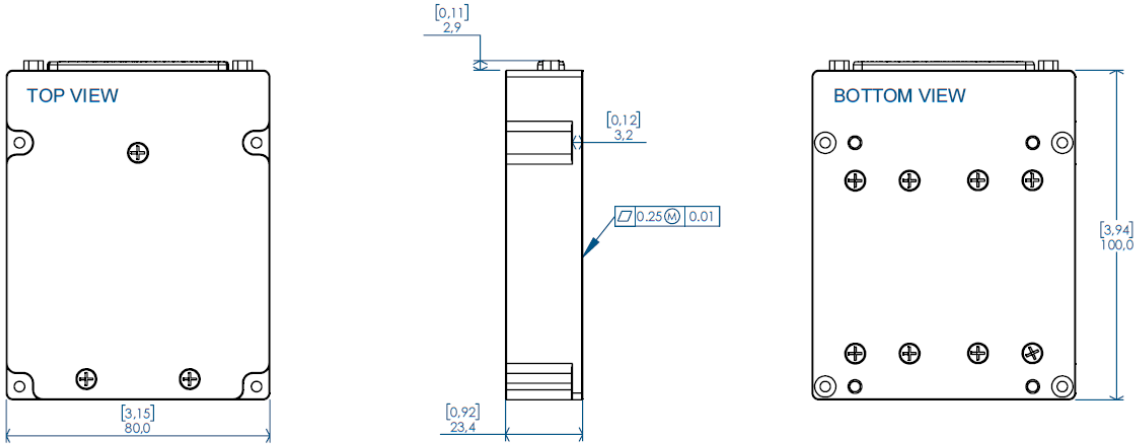


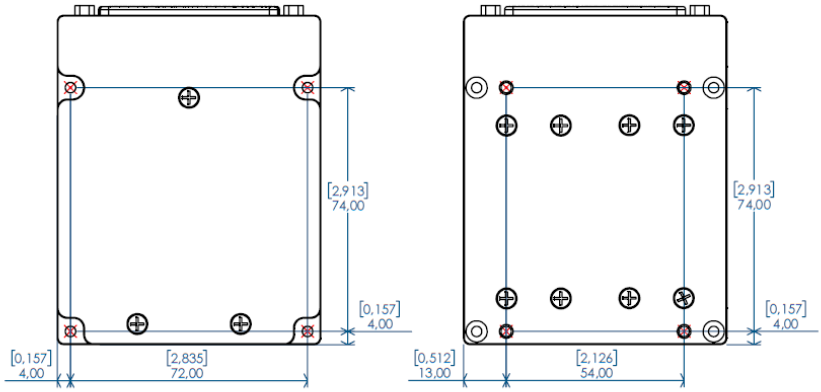

**Figure U.** Recommended Application Series Connection

**DOR**: Can be either an ORing diode or ideal diode driver circuit

## Mechanical Drawing




For mounting application 1
4 x Ø3.16mm Through Hole

For mounting application 3
4 x M3 Threaded Hole (5mm deep)

For mounting application 2
4 x M3 Helicoil

M3 screw should not exceed 3mm (0.118") depth below the surface of the thermal interface

Heat Dissipation Surface

Apply 0.077mm (0.003") thick Arctic Alumina or equivalent thermal compound to the area indicated by the heat dissipation surface before mounting.

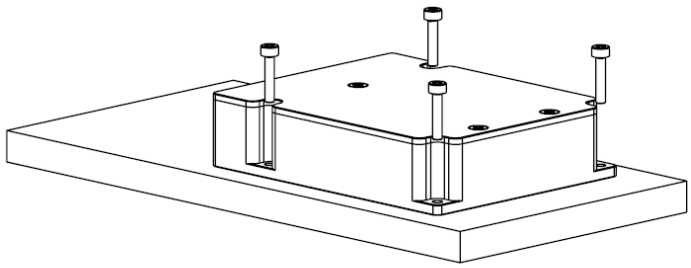
NOTES:

- APPLIED TORQUE PER M3 SCREW 1.5Nm (13in-lb) RECOMMENDED [1.6Nm (14in-lb) LIMIT].
- RECOMMENDED COOLING METHOD: CONDUCTION COOLED.
- THERMAL INTERFACE FLATNESS TOLERANCE IS 0.25mm (0.01") TIR FOR SURFACE.
- CONNECTOR MPN: 164A17969X
- MATE MPN: 163A11099X or EQ.
- BACKSHELL: 165X02719X or EQ.
- CASE MATERIAL: AL6061-T6
- FINISH: MIL-C-5541 / Type II, Class 1A
- WEIGHT: 340g (12oz)
- ALL DIMENSIONS IN MILIMETERS [inches]
- TOLERANCES:
  X.Xmm ±0.5mm (X.XXIN ±0.020)
  X.XXmm ±0.25mm (X.XXXIN ±0.010)

| Pin | Name | Function |
|---|---|---|
| 4 | CHASSIS | Earth |
| 1, 3, 21 | +IN | Positive input voltage |
| 23 | ON/OFF | Remote on/off, referenced to -IN |
| 2, 20, 22 | -IN | Input return |
| 11, 13, 15, 17, 29, 30, 32, 34, 36 | -OUT | Output return |
| 27 | -SNS | Negative remote sense |
| 8 | TRIM | Output voltage trim |
| 26 | +SNS | Positive remote sense |
| 12, 14, 16, 18, 19, 31, 33, 35, 37 | +OUT | Positive output voltage |
| | | |
| 25* | PMBUS_SDA | I2C Data |
| 24* | PMBUS_SCL | I2C Clock |
| 5* | PMBUS_ADDRESS | I2C Address selection |
| | | |
| 6, 7, 9, 10, 28 | NC | DO NOT CONNECT |
| | | |
| | | |
| | | |

*: AVAILABLE ON PMBUS OPTION (ALL REFERENCED TO -OUT)

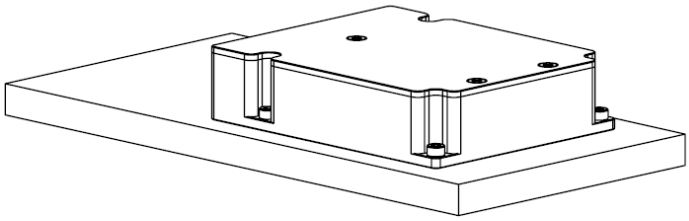
## Mounting Applications

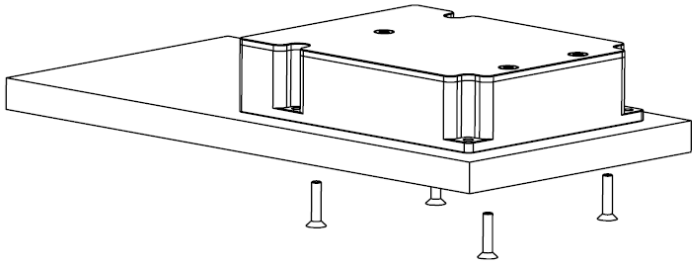


For mounting application 1;

Using four M3 cylindrical head screws, M3 washers and M3 spring washers, you can assemble as shown in the example.

Pay attention to the notes on the previous page before assembly.

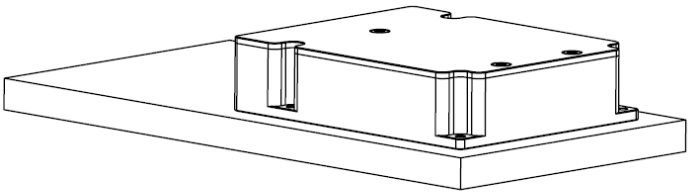


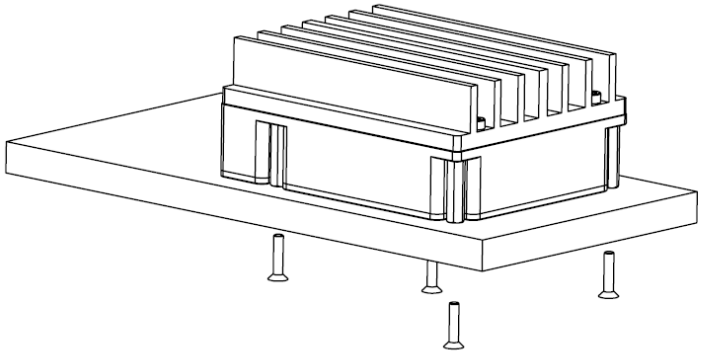


For mounting application 2;

Using four M3 countersunk screws, you can assemble as shown in the example.

Pay attention to the notes on the previous page before assembly.

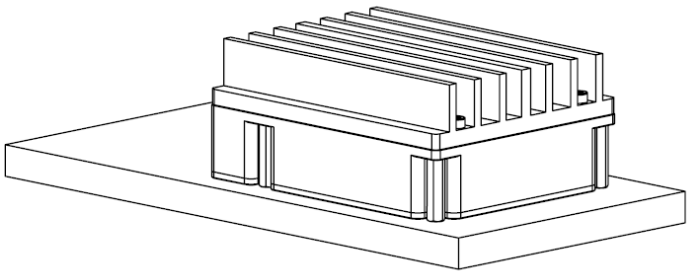




For mounting application 3;

Using a heatsink and four M3 countersunk screws, you can assemble as shown in the example.

Pay attention to the notes on the previous page before assembly.



## Part Ordering Information

| Family | Input Voltage | Power | Output Voltage | Package | Option Field |
|---|---|---|---|---|---|
| **KMRM01** | **DC28**<br>28 VDC | **P300**<br>300 W | **DC28**<br>28 VDC | **CM**<br>Custom Module | **PM:** PMBUS<br>**PR:** Droop Active |

| Ordering Number | Communication | Droop |
|---|---|---|
| **KMRM01-DC28-P300-DC28-CM** | No communication capability | Passive |
| **KMRM01-DC28-P300-DC28-CM-PR** | No communication capability | Active |
| **KMRM01-DC28-P300-DC28-CM-PM** | With PMBUS communication capability | Passive |
| **KMRM01-DC28-P300-DC28-CM-PM-PR** | With PMBUS communication capability | Active |

## Revision History

| Revision | Date | Description | Page Number(s) |
|---|---|---|---|
| **A-PC1** | 17.03.2023 | Initial Release | - |
| **A-PC2** | 04.10.2023 | - | All |
| **A-PC3** | 08.11.2023 | - | All |

## Contact

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