# Features

# Power Module

- Wide Vin 5 to 60VDC
- High power density (LxWxH = 12.19x12.19x3.75)
- Wide operating temperature -40°C to 100°C at full load
- Efficiency up to 97%, no need for heat-sinks
- 6-sided shielding
- Thermally and EMI enhanced 25 pad LGA package
- Low profile

RECOM
DC/DC Converter

# RPMH-1.5

## 1.5 Amp Single Output

YEAR 3 warranty


EN55032 compliant

## Description

The RPMH-1.5 series is a wide input voltage, 1.5A non-isolated switching regulator power module. The module accepts up to 60VDC input and provides a trimmable output from 2.6 up to 28VDC and comes complete with a full set of features including adjustable output, on/off control, and power good signals. The ultra-compact module has a profile of only 3.75mm, but with an efficiency of up to 97%, the device can operate at full load in ambient temperatures as high as +100°C and with power derating up to 105°C without forced air cooling. The package is complete with 6-sided shielding for optimal EMC performance and excellent heat management.

## Selection Guide

| Part Number | Input Voltage Range [1] [VDC] | Output Voltage [VDC] | Vout Adjust Range [VDC] | Output Current max. [2] [A] | Efficiency typ. full load [%] | Max Capacitive typ. Load [3] [mF] |
|---|---|---|---|---|---|---|
| RPMH3.3-1.5 | 5 - 60 | 3.3 | 2.64 - 3.63 | 1.5 | 73 | 31.2 |
| RPMH5.0-1.5 | 7 - 60 | 5 | 4 - 5.5 | 1.5 | 80 | 21.2 |
| RPMH12-1.5 | 14 - 60 | 12 | 7.2 - 13.2 | 1.5 | 88 | 8.1 |
| RPMH15-1.5 | 17 - 60 | 15 | 9 - 16.5 | 1.5 | 90 | 5.9 |
| RPMH24-1.5 | 26 - 60 | 24 | 15 - 28 | 1.5 | 92 | 3.4 |

**Notes:**

Note1: Input voltage must be higher than desired output voltage. Refer to **"Buck mode"** and **"100% duty cycle mode [5]"**

Note2: Refer to **"Derating Graph"**

Note3: Max. Capacitive typ. Load is tested at nominal input and full resistive load. Max. rated output current within 1s

## Model Numbering

RPMH__-1.5-__ Packaging [4]

Output Voltage

max. Output Current

**Notes:**

Note4: Add suffix "-CT" for tube packaging. For more details refer to **"PACKAGING INFORMATION"** without suffix, standard tape and reel packaging

EVAL BOARD available

www.recom-power.com/eval-ref-boards

## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

| Parameter | Condition | | | Min. | Typ. | Max. |
|---|---|---|---|---|---|---|
| Internal Input Filter | | | | | | capacitor |
| Input Voltage Range | Buck mode | 3.3Vout<br>5Vout<br>12Vout<br>15Vout<br>24Vout | | 5VDC<br>7VDC<br>14VDC<br>17VDC<br>26VDC | 48VDC | 60VDC |
| | 100% duty cycle mode [5] | Vout= Vin - Vdrop | 3.3Vout<br>5Vout<br>12Vout<br>15Vout<br>24Vout | 3VDC | | 5VDC<br>7VDC<br>14VDC<br>17VDC<br>26VDC |
| Absolute Maximum Input Voltage | | | | | | 66VDC |
| Input Current | nom. Vin= 48VDC | 3.3Vout<br>5Vout<br>12Vout<br>15Vout<br>24Vout (1.33A) | | | 140mA<br>194mA<br>420mA<br>512mA<br>750mA | |
| Quiescent Current (Vin nominal) | nom. Vin= 48VDC | 3.3Vout, 5Vout<br>12Vout, 15Vout<br>24Vout | | | 35µA<br>85µA<br>190µA | |
| Quiescent Current (max. Duty Cycle) | nom. Vin= 48VDC | 3.3Vout<br>5Vout<br>12Vout<br>15Vout<br>24Vout | | | 750µA<br>60µA<br>130µA<br>160µA<br>262µA | |
| Internal Power Dissipation | nom. Vin= 48VDC | 3.3Vout<br>5Vout<br>12Vout<br>15Vout<br>24Vout (1.33A) | | | 1.75W<br>1.81W<br>2.14W<br>2.27W<br>2.16W | 2.12W<br>2.22W<br>2.62W<br>2.72W<br>2.66W |
| Output Voltage Trimming | refer to **"OUTPUT VOLTAGE TRIMMING"** | | | 2.64VDC | | 28VDC |
| Minimum Dropout Voltage (Vdrop) | Vin min. = Vdrop + Vout | 3.3Vout, 5Vout | | | 1.5V/A | |
| | | others | | | 2V/A | |
| Minimum Load | | | | 0% | | |
| Start-up Time | power up by using CTRL function | | | 7.2ms | 12ms | 20.5ms |
| Rise-time | | | | | 8ms | |
| ON/OFF CTRL | DC-DC ON<br>DC-DC OFF | | | | | Open or 1.22V<$V_{CTRL}$<Vin<br>Short or -0.3V<$V_{CTRL}$<1.144VDC |
| Standby Current | Vin=12VDC<br>nom. Vin=48VDC | DC-DC ON<br>DC-DC OFF | | 16µA | 19µA<br>56µA | 70µA |
| Internal Operating Frequency | | | | | 1MHz | |
| Output Ripple and Noise [6] | 20MHz BW | 3.3Vout | | | 70mVp-p | |

**Notes:**

Note5: As input approaches output voltage set point, device enters maximum duty cycle mode. In 100% duty cycle mode, Vout equals Vin minus dropout voltage. Please refer to **"Dropout Voltage vs. Load"**. Output capacitor required. Please refer to **"Output Capacitor"**

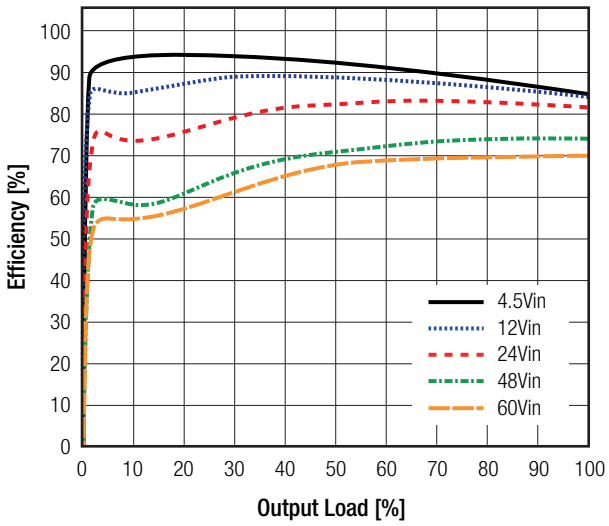
Note6: Measurements for Ripple and Noise are made with input EMC filter and output capacitors 22uF/50V MLCC for 12V, 15V, and 24V output voltage across output (low ESR)

**continued on next page**

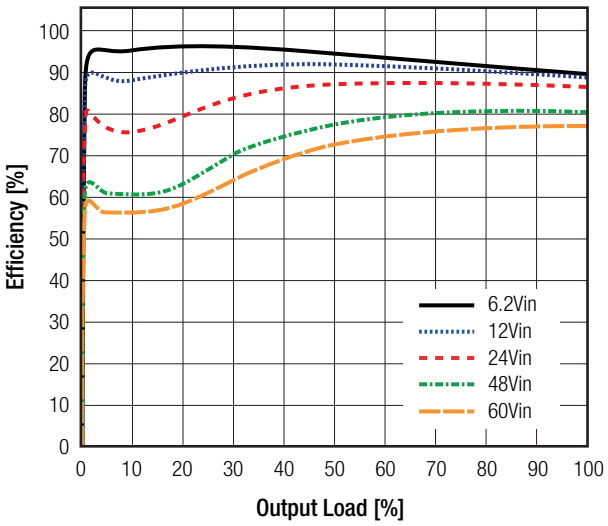
## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

### Efficiency vs. Load

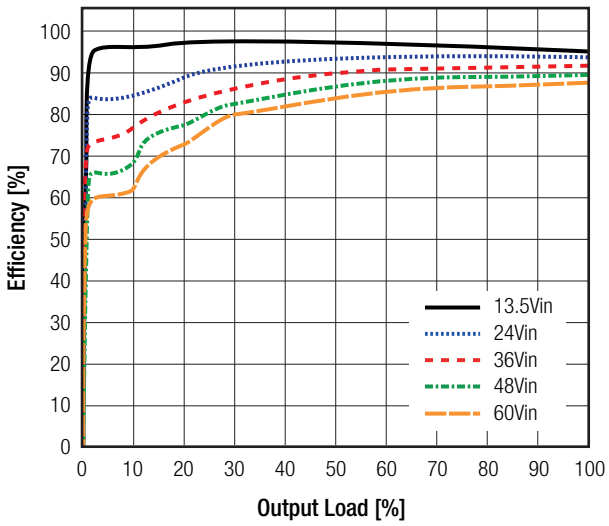
RPMH3.3-1.5



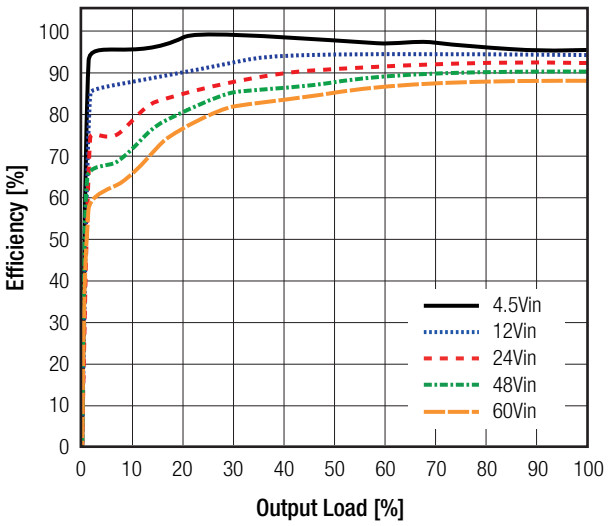

RPMH5.0-1.5



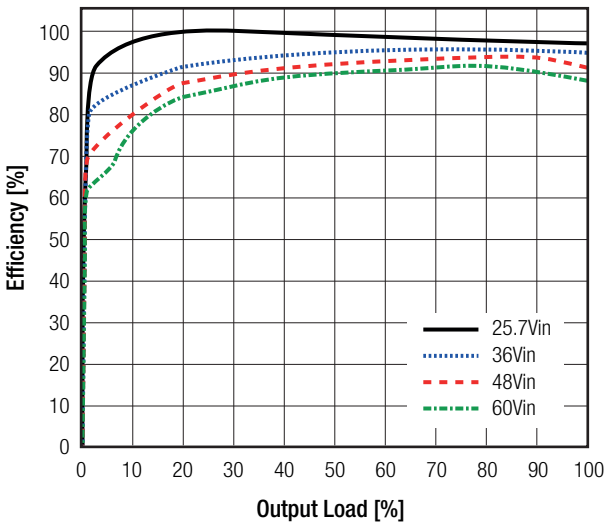

RPMH12-1.5




RPMH15-1.5




RPMH24-1.5

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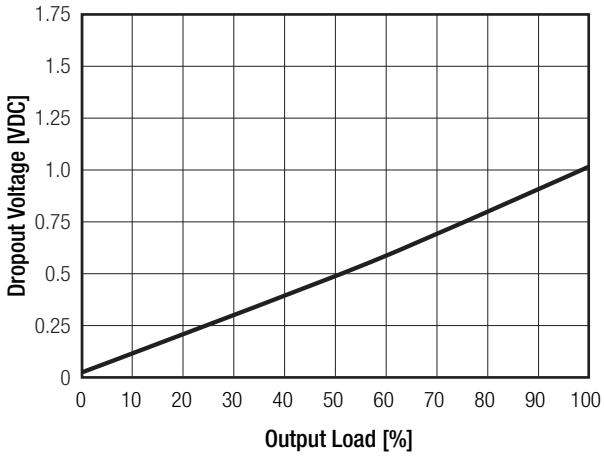
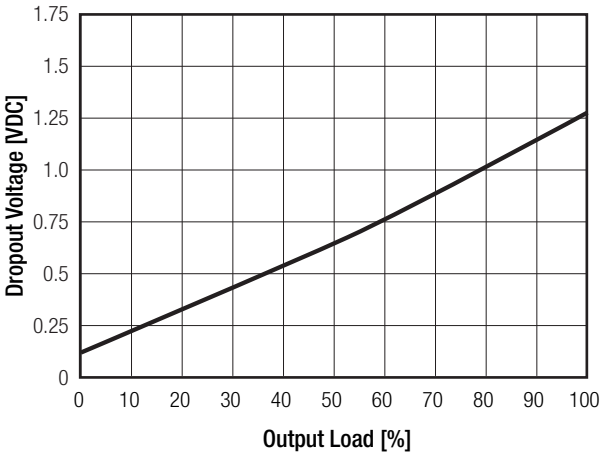
## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

### Dropout Voltage vs. Load

RPMH3.3-1.5, and RPMH5.0-1.5




RPMH12-1.5, RPMH15-1.5, and RPMH24-1.5




### Output Capacitor

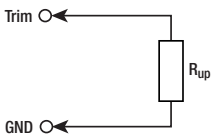
The RPMH requires MLCC output capacitor for normal operation (see below table)

| Output Capacitance | |
|---|---|
| $Vout_{nom}$ | $C_{OUT}$ |
| 12VDC | 22µF 50V X7R |
| 15VDC | |
| 24VDC | |

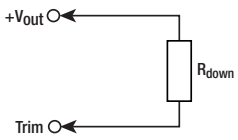
## OUTPUT VOLTAGE TRIMMING

The RPMH-Series offers the feature of trimming the output voltage over a range between -20% to +10% for lower output voltages and from -40% to +10% for higher output voltages. This can be done by using external trim resistors. The values for the trim resistors in trim tables are according to standard E96 values; therefore, the specified voltage may slightly vary. Refer to **"Selection Guide"**

Trim up




Trim down




| | | |
|---|---|---|
| $Vout_{nom}$ | = nominal output voltage | [VDC] |
| $Vout_{set}$ | = trimmed output voltage | [VDC] |
| $R_{up}$ | = trim up resistor | [Ω] |
| $R_{down}$ | = trim down resistor | [Ω] |
| $R_{HI}$ , $R_{LO}$ | = internal resistors | [Ω] |

| $Vout_{nom}$ | $R_{HI}$ | $R_{LO}$ |
|---|---|---|
| 3.3VDC | 100kΩ | 43.2kΩ |
| 5VDC | 100kΩ | 24.9kΩ |
| 12VDC | 100kΩ | 9.09kΩ |
| 15VDC | 100kΩ | 7.15kΩ |
| 24VDC | 100kΩ | 4.32kΩ |

**Calculation:**

$$R_{up} = \frac{R_{HI} \times R_{LO} \times Vout_{nom}}{(Vout_{set} - Vout_{nom}) \times (R_{HI} + R_{LO})}$$

$$R_{down} = R_{HI} \times \left[ \frac{(Vout_{set} - Vout_{nom}) \times R_{LO} + Vout_{set} \times R_{HI}}{(Vout_{nom} - Vout_{set}) \times (R_{HI} + R_{LO})} \right]$$

**Practical Example RPMH3.3-1.5, trim up**

$Vout_{set}$ = 3.63VDC

$$R_{up} = \frac{100k \times 43.2k \times 3.3}{(3.63 - 3.3) \times (100k + 43.2k)} = 301.676k\Omega$$

$R_{up}$ according to E96 ≈ **301kΩ**

**Practical Example RPMH3.3-1.5, trim down**

$Vout_{set}$ = 2.64VDC

$$R_{down} = 100k \times \left[ \frac{(2.64 - 3.3) \times 43.2k + 2.64 \times 100k}{(3.3 - 2.64) \times (100k + 43.2k)} \right] = 249.162\Omega$$

$R_{down}$ according to E96 ≈ **249kΩ**

continued on next page

## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

### RPMH3.3-1.5

**Trim up**

| $V_{out}$set = | 3.4 | 3.45 | 3.5 | 3.63 | [VDC] |
|---|---|---|---|---|---|
| $R_{up}$ (E96) ≈ | 1M | 665k | 499k | 301k | [Ω] |

**Trim down**

| $V_{out}$set = | 3.1 | 3 | 2.8 | 2.64 | [VDC] |
|---|---|---|---|---|---|
| $R_{down}$ (E96) ≈ | 1M05 | 665k | 365k | 249k | [Ω] |

### RPMH5.0-1.5

**Trim up**

| $V_{out}$set = | 5.1 | 5.3 | 5.5 | [VDC] |
|---|---|---|---|---|
| $R_{up}$ (E96) ≈ | 1M | 332k | 200k | [Ω] |

**Trim down**

| $V_{out}$set = | 4.7 | 4.5 | 4.3 | 4 | [VDC] |
|---|---|---|---|---|---|
| $R_{down}$ (E96) ≈ | 1M24 | 698k | 475k | 301k | [Ω] |

### RPMH12-1.5

**Trim up**

| $V_{out}$set = | 12.4 | 12.6 | 12.8 | 13 | 13.2 | [VDC] |
|---|---|---|---|---|---|---|
| $R_{up}$ (E96) ≈ | 249k | 165k | 124k | 100k | 82.5k | [Ω] |

**Trim down**

| $V_{out}$set = | 10 | 9.6 | 9 | 8.5 | 8 | 7.7 | 7.2 | [VDC] |
|---|---|---|---|---|---|---|---|---|
| $R_{down}$ (E96) ≈ | 453k | 357k | 267k | 215k | 174k | 154k | 130k | [Ω] |

### RPMH15-1.5

**Trim up**

| $V_{out}$set = | 15.5 | 15.7 | 15.9 | 16.1 | 16.3 | 16.5 | [VDC] |
|---|---|---|---|---|---|---|---|
| $R_{up}$ (E96) ≈ | 200k | 143k | 110k | 90k9 | 76k8 | 66k5 | [Ω] |

**Trim down**

| $V_{out}$set = | 14.5 | 14 | 13.5 | 13 | [VDC] |
|---|---|---|---|---|---|
| $R_{down}$ (E96) ≈ | 2M67 | 1M30 | 825k | 604k | [Ω] |

### RPMH24-1.5

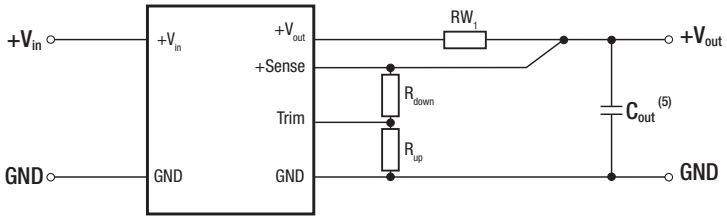
**Trim up**

| $V_{out}$set = | 24.5 | 25 | 25.5 | 26 | 26.5 | 27 | 28 | [VDC] |
|---|---|---|---|---|---|---|---|---|
| $R_{up}$ (E96) ≈ | 200k | 100k | 66k5 | 49k9 | 40k2 | 33k2 | 24k9 | [Ω] |

**Trim down**

| $V_{out}$set = | 20.1 | 19.6 | 18 | 17.6 | 17 | 16.5 | [VDC] |
|---|---|---|---|---|---|---|---|
| $R_{down}$ (E96) ≈ | 487k | 422k | 280k | 261k | 226k | 205k | [Ω] |

## REMOTE SENSE




$RW_1$ ... wire losses +
$R_{up}$ ... trim up resistor
$R_{down}$ ... trim down resistor

The output voltage can be adjusted via the trim and sense functions. The maximum output voltage from trim and sense function combined is listed in the table below. Derating may be required when using trim and/or sense functions.

| $V_{out\,nom}$ | Vout max. |
|---|---|
| 3.3VDC | 3.63VDC |
| 5VDC | 5.5VDC |
| 12VDC | 13.2VDC |
| 15VDC | 16.5VDC |
| 24VDC | 28VDC |

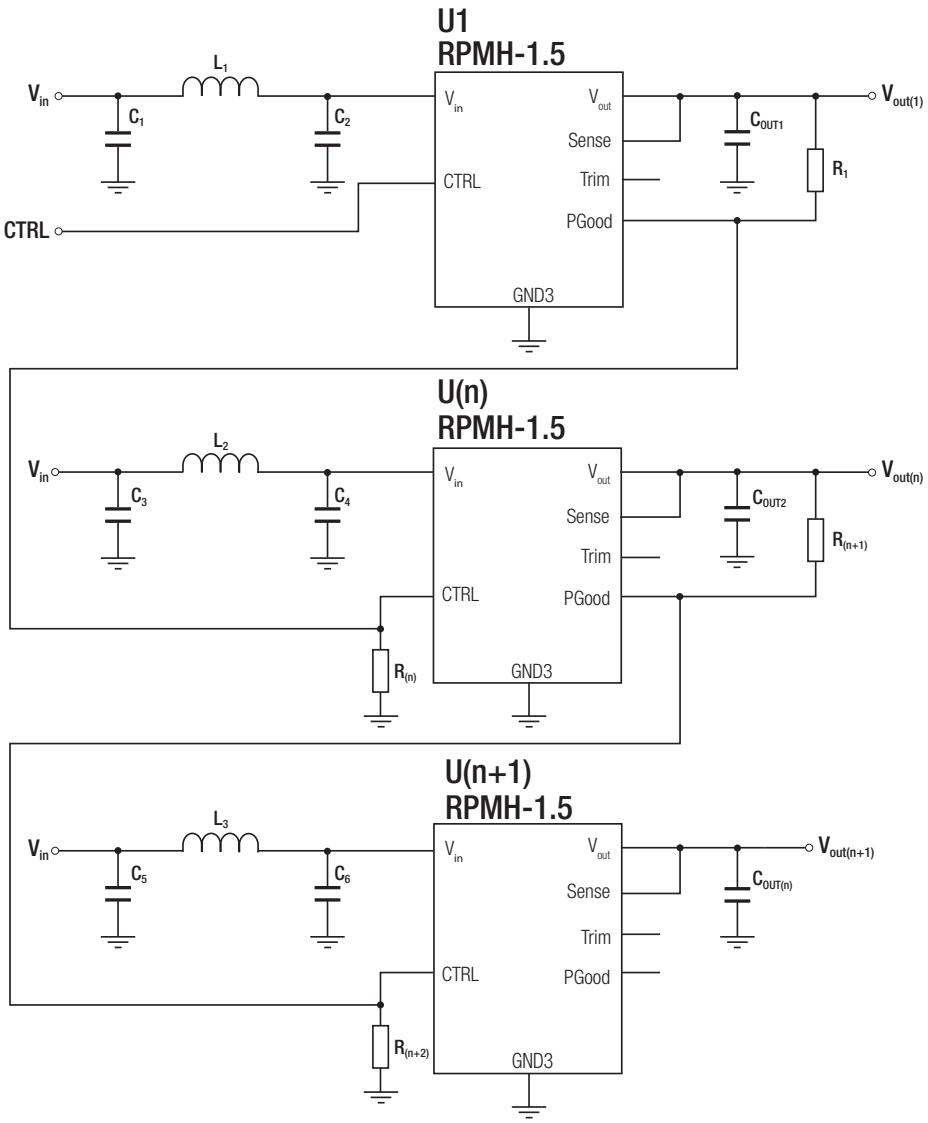
## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

| REGULATIONS | | |
|---|---|---|
| **Parameter** | **Condition** | **Value** |
| Output Accuracy | | ±2.0% typ. / ±4% max. |
| Line Regulation | low line to high line, full load | ±3.0% typ. |
| Load Regulation | 10% to 100% load | 0.8% typ. |
| Transient Response | 25% load step change | 100mVp-p |
| | recovery time | 2ms |

### Sequencing Multiple Modules

To sequence multiple power module, the power good (PGOOD) pad and the CTRL pad may be used. In below schematic, the U2 starts after U1 (RPMHxx-1.5) reaches its set output voltage and the power good signal is set to high which then enables U2. After U2 reaches its set output voltage, it enables next module - until U(n).

Note that by default PGOOD pad is pulled high to internal Vcc (5 VDC) and CTRL of enabled modules are pulled up to Input Voltage. Accordingly, external pull-up and pull-down resistors (R1-R(n+2)) must be used to secure proper sequencing.



## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

| PROTECTIONS | | | |
|---|---|---|---|
| **Parameter** | **Condition** | | **Value** |
| Short Circuit Protection (SCP) | $V_{FB} < 0.4V$ | | hiccup mode, automatic recovery, 95-99ms |
| Short Circuit Input Current | without soft-start mode | | 15µA |
| Over Current Protection (OCP) | nom. Vin | 3.3Vout<br>5Vout<br>12Vout<br>15Vout<br>24Vout | 135%<br>130%<br>120%<br>110%<br>110% |
| Over Temperature Protection (OTP) | case temperature<br>(measured on tc point) | DC-DC OFF<br>DC-DC ON | 105°C min., auto restart after cool down<br>100°C typ. |

| ENVIRONMENTAL | | | |
|---|---|---|---|
| **Parameter** | **Condition** | | **Value** |
| Operating Temperature Range [7] | @ natural convection 0.1m/s (refer to **"Derating Graph"**) | | -40°C to +100°C |
| Maximum Case Temperature | measured on tc point (refer to **"Dimension Drawing"**) | | +105°C |
| Temperature Coefficient | @ +60°C $T_{AMB}$ | | 0.63%/K |
| Thermal Impedance [7] | natural convection 0.1m/s, horizontal ($T_{case}$ to $T_{AMB}$) | | 12.8K/W typ. |
| Operating Altitude | @ natural convection 0.1m/s | | 5000m |
| Shock | MIL-STD-810G, Method 516.6, Procedure I | | 40g, 11ms, saw-tooth, 3 shocks ± per axis 3 axis; unit is operating |
| | MIL-STD-810G, Method 516.6, Procedure IV | | drop on 50mm plywood or concrete 26 times from 1 meter |
| Random Vibration | MIL-STD-810G, Method 514.6, Procedure I, Category 24 | | Category 24 - Figure 514.6E-1 - power spectral density<br>= $0.04g^2$/Hz at 20Hz –1000Hz;<br>-6dB/octave at 1000Hz – 2000Hz;<br>60 minutes x 3 axis; unit is operating during tests |
| Moisture Sensitivity Level | non-condensing | | MLS 1 |
| MTBF | according to MIL-HDBK-217F, G.B. @ full load | +25°C<br>+85°C | 2696 x $10^3$ hours<br>995 x $10^3$ hours |

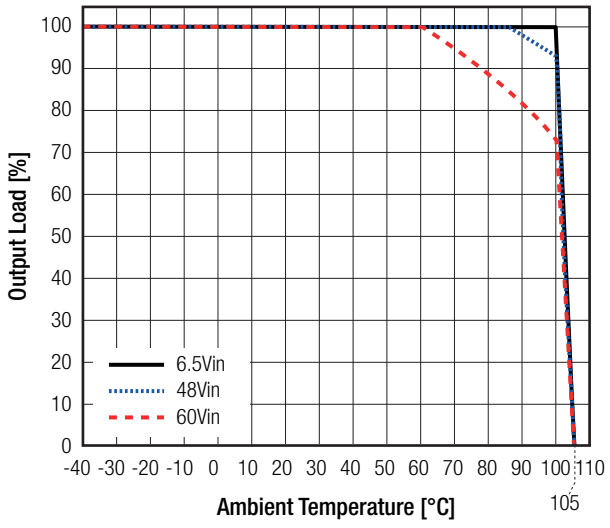
**Notes:**

Note7: tested with a RPMH-1.5-EVM-1 card 85.0x55.0mm 35µm copper, 4 layer

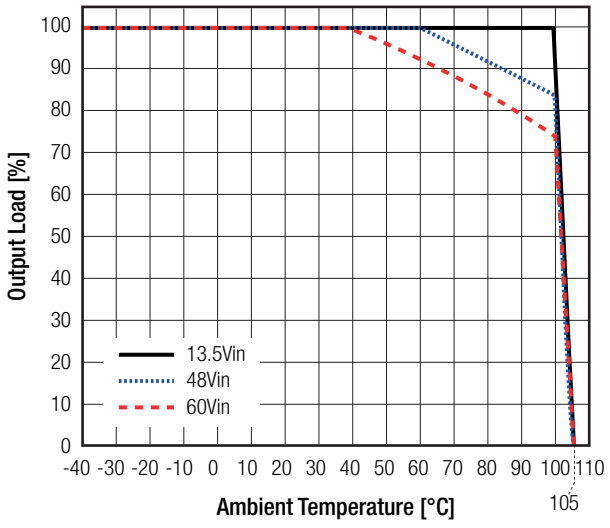
### Derating Graph

(@ chamber and natural convection 0.1m/s)

RPMH3.3-1.5, RPMH5.0-1.5




RPMH12-1.5

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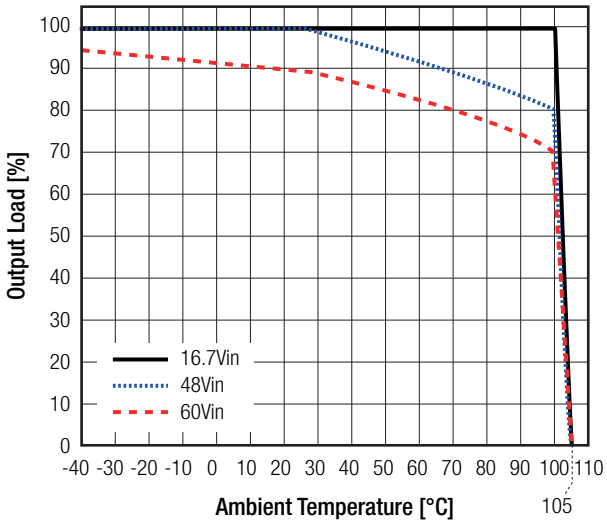
## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

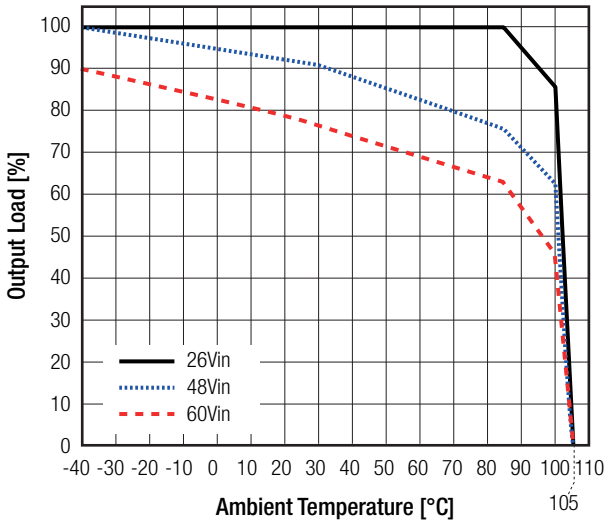
### Derating Graph

(@ chamber and natural convection 0.1m/s)

RPMH15-1.5




RPMH24-1.5

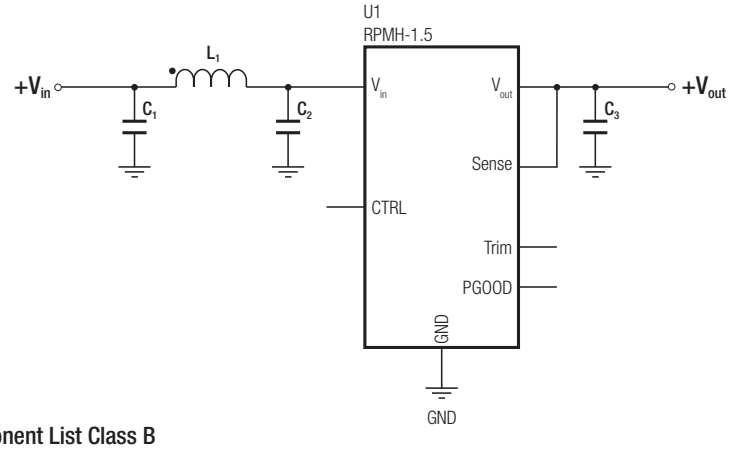



## SAFETY AND CERTIFICATIONS

| Certificate Type (Safety) | Report / File Number | Standard |
|---|---|---|
| Audio/video, information, and communication technology equipment. Safety requirements | designed to meet | EN62368-1 |
| RoHS2 | | RoHS 2011/65/EU + AM2015/863 |

| EMC Compliance | Condition | Standard / Criterion |
|---|---|---|
| Electromagnetic compatibility of multimedia equipment - emission requirements | with external components (refer to **"EMC filtering suggestion"** below) | EN55032, Class B |

### EMC filtering suggestion according to EN55032



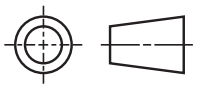

Component List Class B

| U1 | L1 | C1 | C2 | C3 |
|---|---|---|---|---|
| RPMH3.3-1.5 | 4.7µH 1.5A 180mΩ | 3.3µF 100V X7R or X7S | 2.2µF 100V X7R | - |
| RPMH5.0-1.5 | | | | - |
| RPMH12-1.5 | 5.6µH 1.7A 180mΩ | | | 22µF 50V X7R |
| RPMH15-1.5 | 10µH 1.5A 180mΩ | | 3.3µF 100V X7R or X7S | |
| RPMH24-1.5 | | 4.7µF 100V X7S | | |

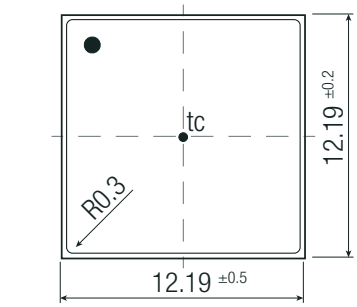
## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

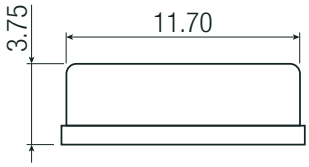
### DIMENSION AND PHYSICAL CHARACTERISTICS

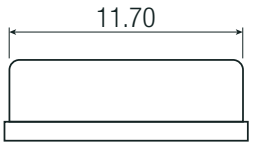
| Parameter | Type | Value |
|---|---|---|
| Material | case<br>PCB<br>solder pads | metal<br>FR4, (UL94 V-0)<br>copper with electrolytic nickel-gold |
| Dimension (LxWxH) | | 12.19 x 12.19 x 3.75mm |
| Weight | | 1.0g typ. |



### Dimension Drawing (mm)



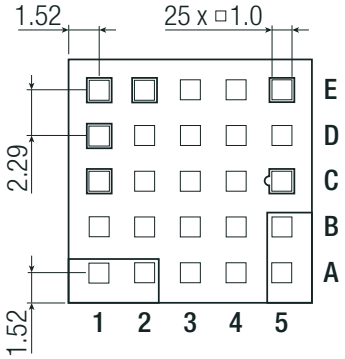

### Pinning information

| Pad # | Function | Description |
|---|---|---|
| A1, A2 | Vin | Positive input voltage with respect to GND. Connect to a Vin plane for enhanced thermal performance |
| C1 | CTRL | Active high: pull to GND to disable the device.<br>Pull high or leave open to enable the device |
| A5, B5 | Vout | Positive output voltage. Connect to a Vout plane for enhanced thermal performance |
| C5 | Sense | Connect this pad to the load or directly to Vout.<br>This pad must not be left floating |
| E5 | Trim | Use this pad to set the output voltage (refer to **"OUTPUT VOLTAGE TRIMMING"** for different Vout) |
| E1, E2 | NC | Not connected |
| D1 | PGood | Output power good. High = VOUT at set level, Low = VOUT below nominal regulation. Sink current is about 0.1mA. It has a high impedance output (100kΩ connected to internal 5V Vcc). Leave floating if not used. |
| others | GND | Negative input voltage. Connect to GND plane(s) for enhanced thermal performance |

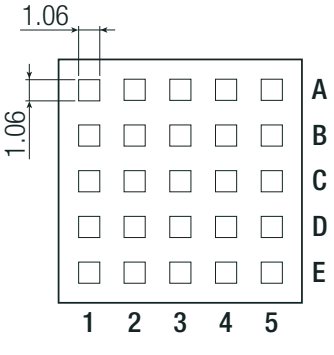
tc = case temperature measuring point
pad tolerance= ±0.05mm
case tolerance= ±0.25mm

### Recommended Footprint Details

#### Bottom View

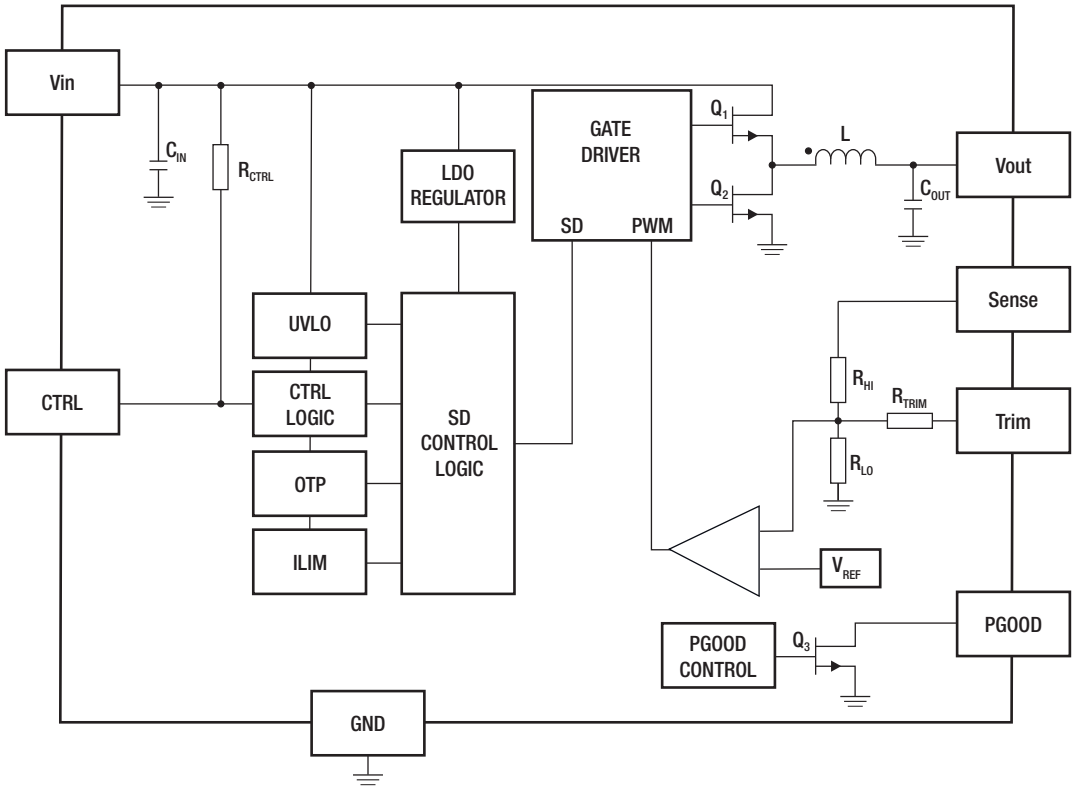



#### Top View



## Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

### BLOCKDIAGRAM




### Component List

| $Vout_{nom}$ | $C_{IN}$ | $R_{CTRL}$ | L | $C_{OUT}$ | $R_{HI}$ | $R_{TRIM}$ | $R_{LO}$ |
|---|---|---|---|---|---|---|---|
| 3.3VDC | 2µF | 1MΩ | 10µH | 20µF | 100kΩ | 1kΩ | 43.2kΩ |
| 5.0VDC | | | | | | | 24.9kΩ |
| 12VDC | | | | 4µF | | | 9.09kΩ |
| 15VDC | | | | | | | 7.15kΩ |
| 24VDC | | | | | | | 4.32kΩ |

### PACKAGING INFORMATION

| Parameter | Type | Value |
|---|---|---|
| Packaging Dimension (LxWxH) | reel (diameter + width) | Ø177.8 x 30.4mm |
| | tape and reel (carton) | 265.0 x 240.0 x 60.0mm |
| | tube ("-CT") | 530.0 x 30.3 x 19.2mm |
| Packaging Quantity | tape and reel | 200pcs |
| | tube ("-CT") | 30pcs |
| Tape Width | | 24mm |
| Storage Temperature Range | | -55°C to +125°C |
| Storage Humidity | non-condensing | 95% RH max. |