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 heatsinks
- 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

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. [%]	Max Capacitive typ. Load [3] [µF]
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

EN55032 compliant

Model Numbering

RPMH ____ -1.5- ____ Packaging [4]

Output Voltage ────┘ └──── max. Output Current
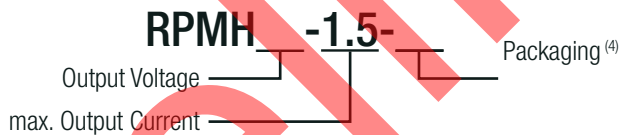
Notes:

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

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

BASIC CHARACTERISTICS

Parameter		Condition		Min.	Typ.	Max.
Internal Input Filter						capacitor
Input Voltage Range	Buck mode	3.3Vout		5VDC	48VDC	60VDC
		5Vout		7VDC		
		12Vout		14VDC		
		15Vout		17VDC		
		24Vout		26VDC		
	100% duty cycle mode [5]	Vout= Vin - Vdrop	3.3Vout	3VDC		5VDC
			5Vout			7VDC
			12Vout			14VDC
			15Vout			17VDC
			24Vout			26VDC
continued on next page						

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

| Parameter	Condition		Min.	Typ.	Max.
Absolute Maximum Input Voltage					66VDC
Input Current	nom. Vin= 48VDC	3.3Vout		140mA	
		5Vout		194mA	
		12Vout		420mA	
		15Vout		512mA	
		24Vout (1.33A)		750mA	
Quiescent Current (Vin nominal)	nom. Vin= 48VDC	3.3Vout, 5Vout		35µA	
		12Vout, 15Vout		85µA	
		24Vout		190µA	
Quiescent Current (max. Duty Cycle)	nom. Vin= 48VDC	3.3Vout		750µA	
		5Vout		60µA	
		12Vout		130µA	
		15Vout		160µA	
		24Vout		262µA	
Internal Power Dissipation	nom. Vin= 48VDC	3.3Vout		1.75W	2.12W
		5Vout		1.81W	2.22W
		12Vout		2.14W	2.62W
		15Vout		2.27W	2.72W
		24Vout (1.33A)		2.16W	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			Open or $1.22V < V_{CTRL} < Vin$	
	DC-DC OFF			Short or $-0.3V < V_{CTRL} < 1.144VDC$	
Standby Current	Vin=12VDC	DC-DC ON	16µA	19µA	70µA
	nom. Vin=48VDC	DC-DC OFF		56µA	
Internal Operating Frequency				1MHz	
Output Ripple and Noise [6]	20MHz BW	3.3Vout		70mVp-p	
Absolute Maximum Capacitive Load	max. rated Output Current within 1s	3.3Vout		31.2mF	
		5Vout		21.2mF	
		12Vout		8.1mF	
		15Vout		5.9mF	
		24Vout		3.4mF	

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)
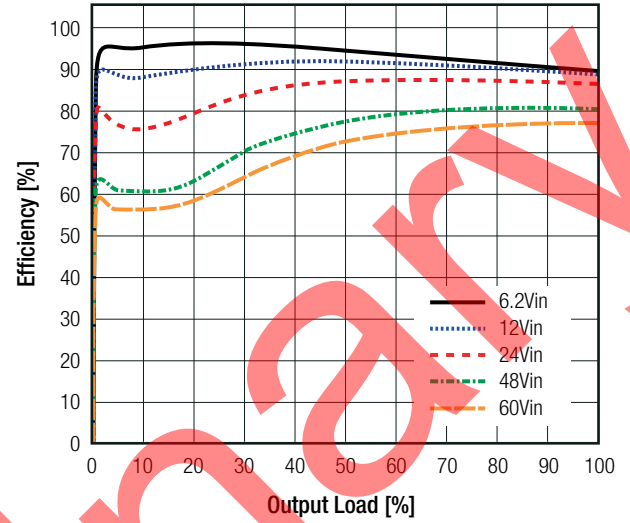
Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)
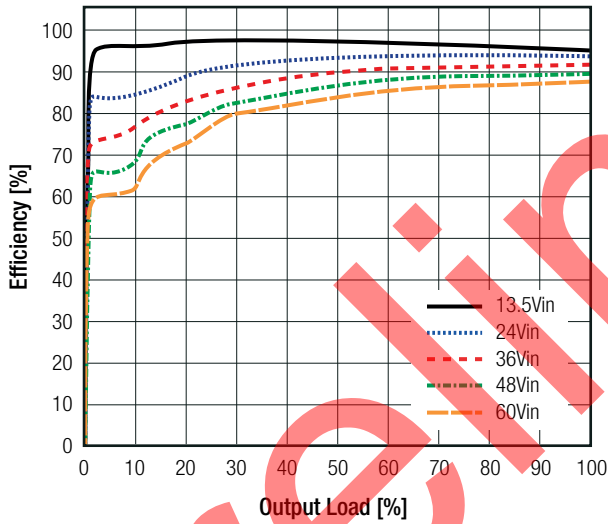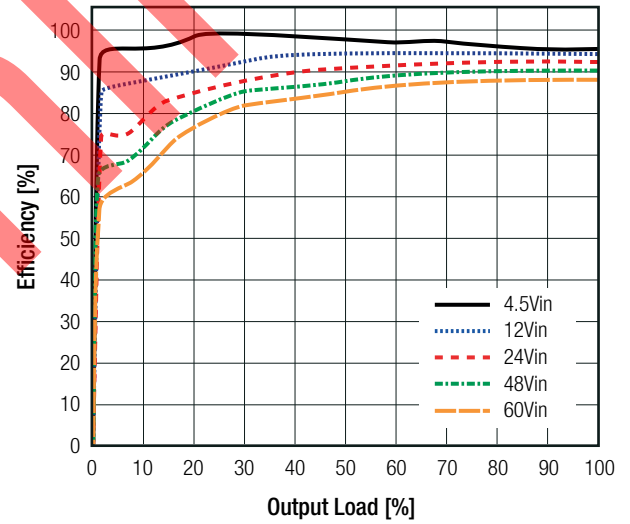
Efficiency vs. Load
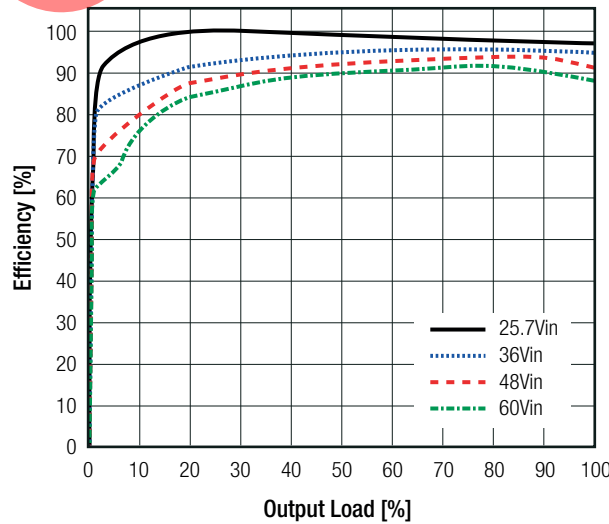
RPMH3.3-1.5
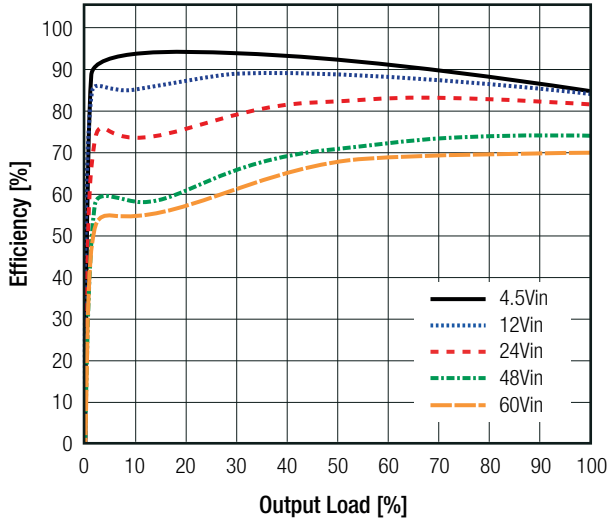
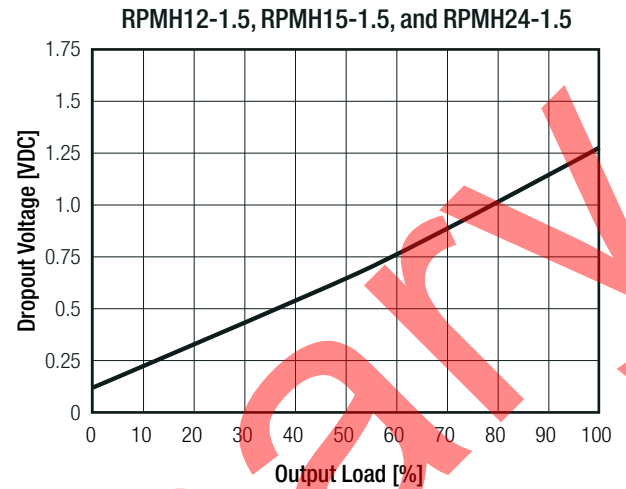### RPMH5.0-1.5
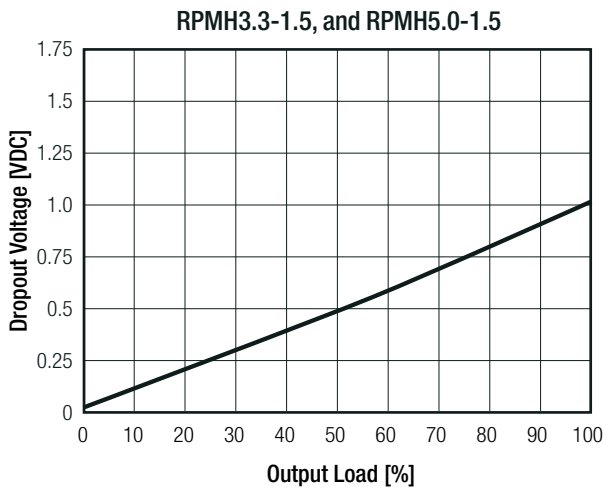

RPMH12-1.5

RPMH15-1.5

RPMH24-1.5

continued on next page

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	
15VDC	22µF 50V X7R
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 ○——

R_{up}

GND ○——

Trim down
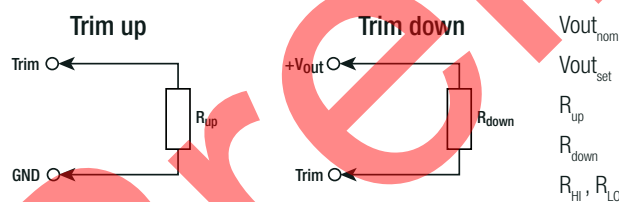
+V_{out} ○——

R_{down}

Trim ○——

$Vout_{nom}$	= 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	100MΩ	9.09MΩ
15VDC	100MΩ	7.15MΩ
24VDC	100MΩ	4.32MΩ

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

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

R_{up} according to E96 ≈ **301kΩ**

Practical Example RPMH3.3-1.5, trim down

$Vout_{set}$ = 2.64VDC

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

R_{down} according to E96 ≈ **249kΩ**

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

Vout$_{set}$ =	3.4	3.45	3.5	3.63	[VDC]
R$_{up}$ (E96) ≈	1M	665k	499k	301k	[Ω]

Trim down

Vout$_{set}$ =	3.1	3	2.8	2.64	[VDC]
R$_{down}$ (E96) ≈	1M05	665k	365k	249k	[Ω]

RPMH5.0-1.5

Trim up

Vout$_{set}$ =	5.1	5.3	5.5	[VDC]
R$_{up}$ (E96) ≈	1M	332k	200k	[Ω]

Trim down

Vout$_{set}$ =	4.7	4.5	4.3	4	[VDC]
R$_{down}$ (E96) ≈	1M24	698k	475k	301k	[Ω]

RPMH12-1.5

Trim up

Vout$_{set}$ =	12.4	12.6	12.8	13	13.2	[VDC]
R$_{up}$ (E96) ≈	249k	165k	124k	100k	82.5k	[Ω]

Trim down

Vout$_{set}$ =	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

Vout$_{set}$ =	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

Vout$_{set}$ =	14.5	14	13.5	13	[VDC]
R$_{down}$ (E96) ≈	2M67	1M30	825k	604k	[Ω]

RPMH24-1.5

Trim up

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

Trim down

Vout$_{set}$ =	20.1	19.6	18	17.6	17	16.5	[VDC]
R$_{down}$ (E96) ≈	487k	422k	280k	261k	226k	205k	[Ω]

REMOTE SENSE
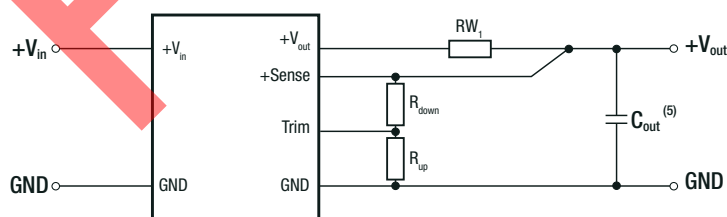
RW$_1$ ... wire losses +
R$_{up}$ ... trim up resistor
R$_{down}$ ... trim down resistor

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.

Vout$_{nom}$	Vout max.
3.3VDC	3.63VDC
5VDC	5.5VDC
12VDC	13.2VDC
15VDC	16.5VDC
24VDC	28VDC

RECOM

DC/DC Converter

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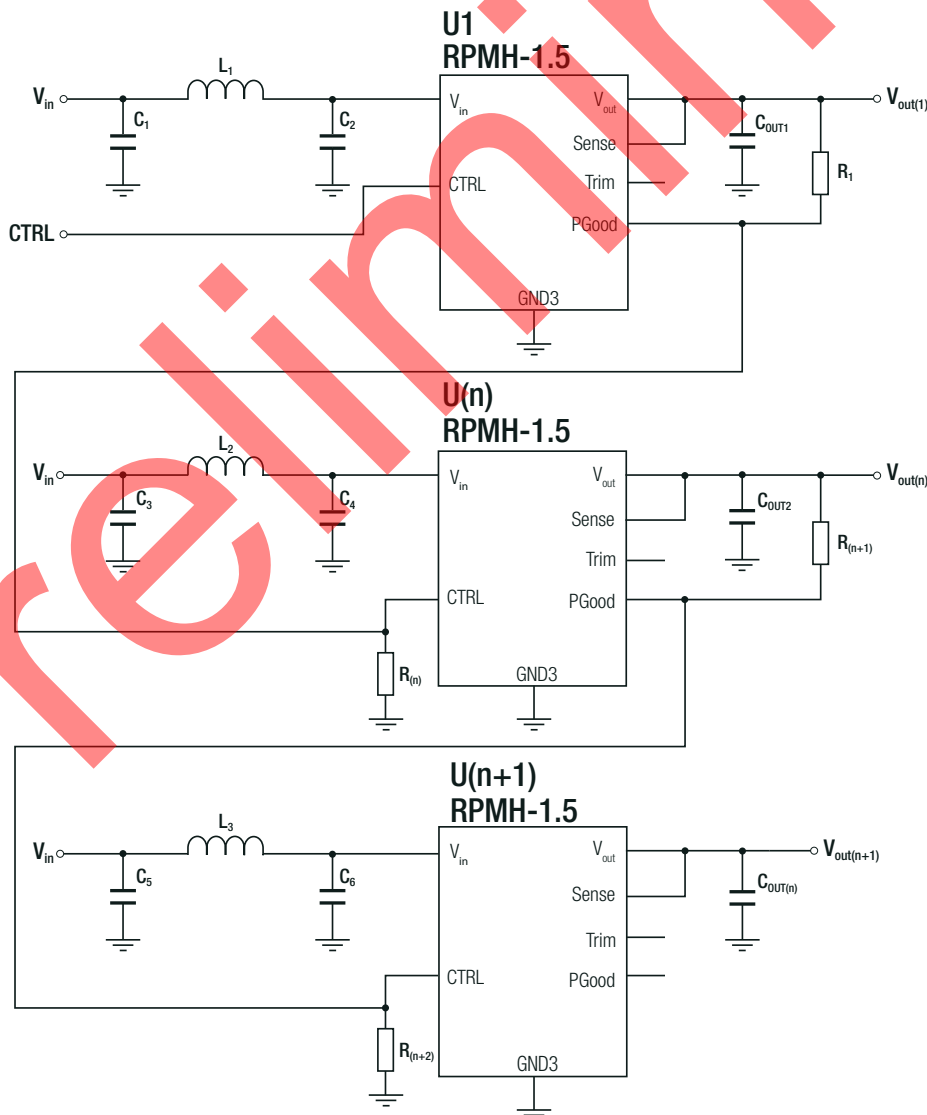
Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

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	135%
		5Vout	130%
		12Vout	120%
		15Vout	110%
		24Vout	110%
Over Temperature Protection (OTP)	case temperature (measured on tc point)	DC-DC OFF	105°C min., auto restart after cool down
		DC-DC ON	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 on 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 = 0.04g²/Hz at 20Hz −1000Hz; -6dB/octave at 1000Hz – 2000Hz; 60 minutes x 3 axis; unit is operating during tests
MTBF	according to MIL-HDBK-217F, G.B. @ full load	+25°C	2696 x 10³ hours
		+85°C	995 x 10³ hours

Notes:

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

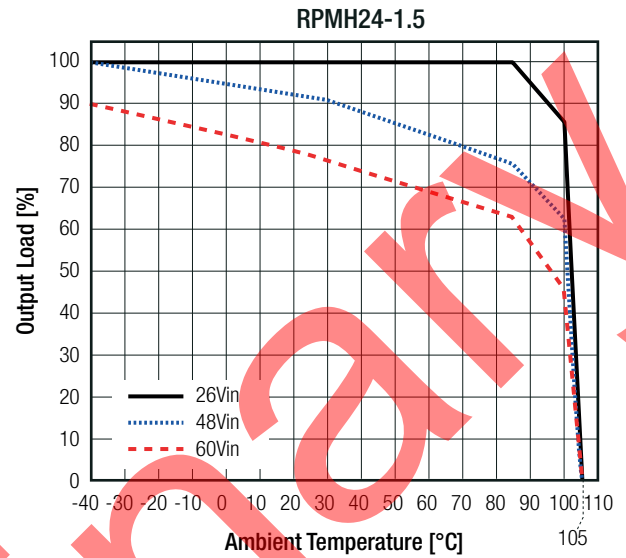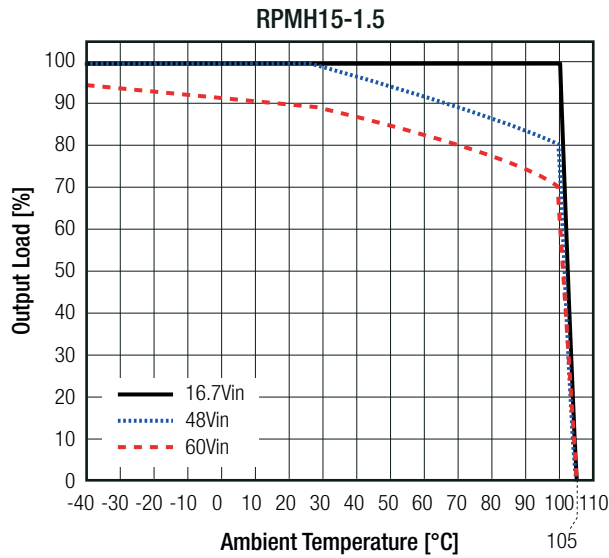### Derating Graph
(@ chamber and natural convection 0.1m/s)
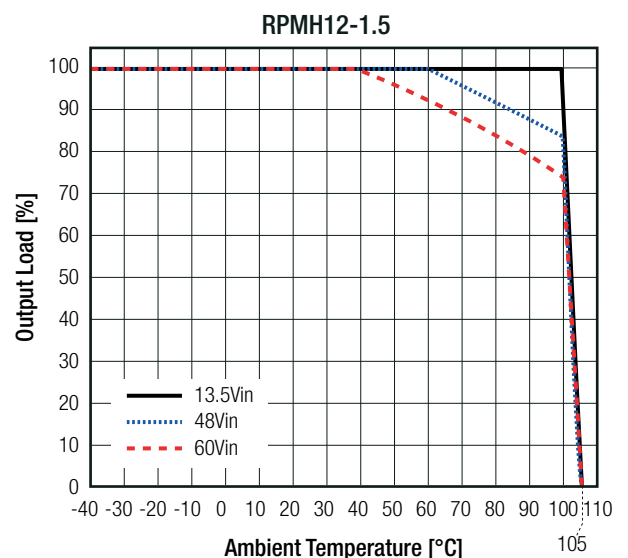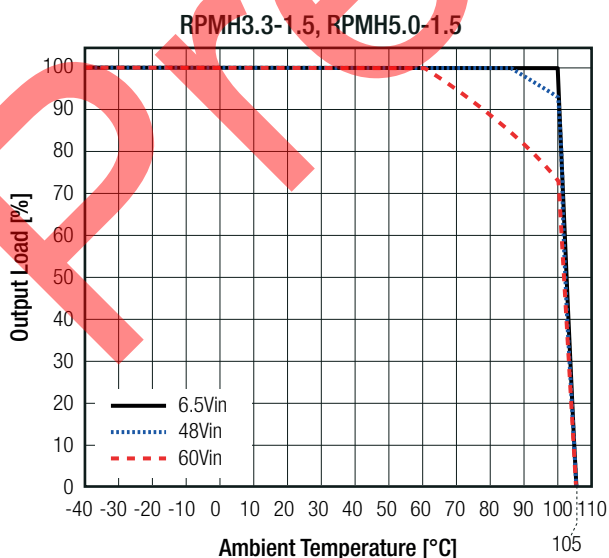
RPMH3.3-1.5, RPMH5.0-1.5

6.5Vin
48Vin
60Vin

RPMH12-1.5

13.5Vin
48Vin
60Vin

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

Legend:
— 16.7Vin
···· 48Vin
--- 60Vin

RPMH24-1.5

Legend:
— 26Vin
···· 48Vin
--- 60Vin

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
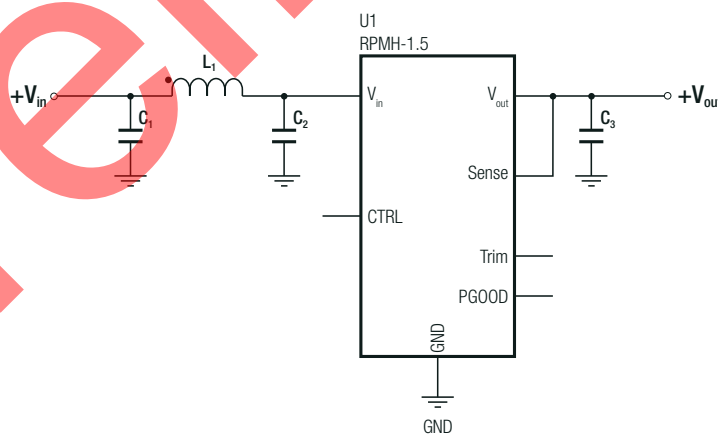
Component List Class B

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

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	metal
	PCB	FR4, (UL94 V-0)
	solder pads	copper with electrolytic nickel-gold
Dimension (LxWxH)		12.19 x 12.19 x 3.75mm
Weight		1.0g typ.
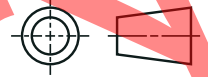
Dimension Drawing (mm)
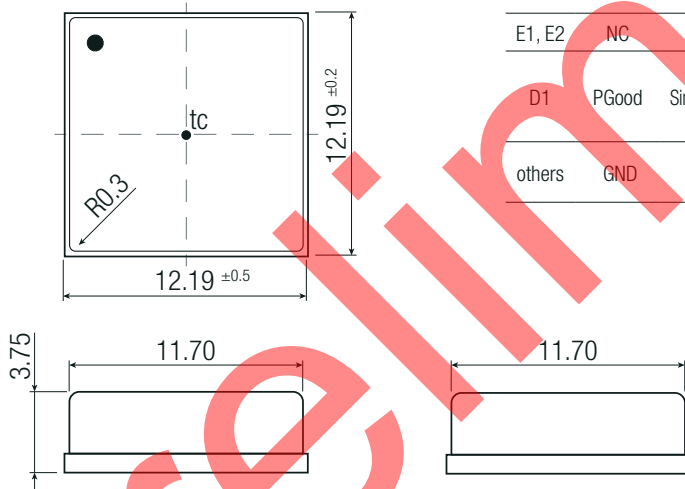
Pinning information

| 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. 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. 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
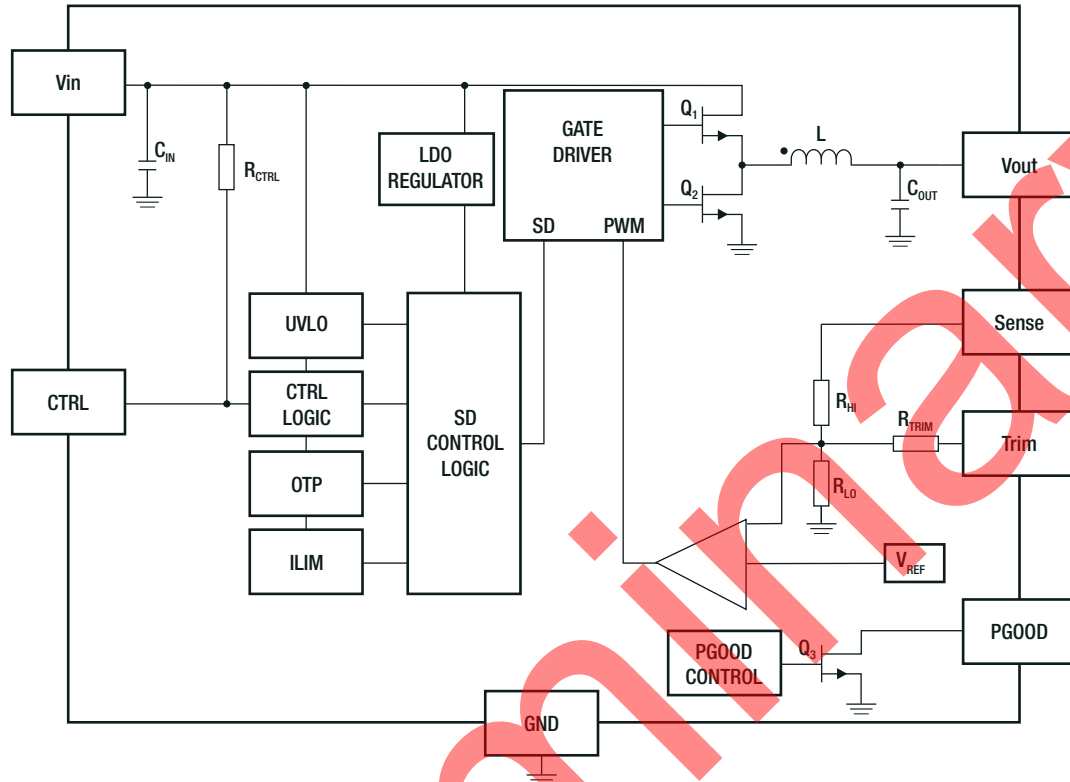case tolerance= ±0.25mm

Recommended Footprint Details

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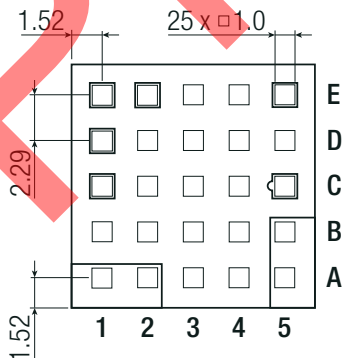
Top View
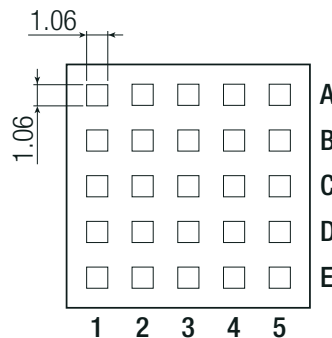
Specifications (@ Ta= 25°C, nom. Vin= 48VDC, full load, with output cap [5] after warm-up unless otherwise stated)

BLOCKDIAGRAM

Component List

Vout$_{nom}$	C$_{IN}$	R$_{CTRL}$	L	C$_{OUT}$	R$_{HI}$	R$_{TRIM}$	R$_{LO}$
3.3VDC				20µF			43.2kΩ
5.0VDC							24.9kΩ
12VDC	2µF	1MΩ	10µH		100kΩ	1kΩ	9.09kΩ
15VDC				4µF			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.
Moisture Sensitivity Level	non-condensing	MLS 1