

Features

Power Module

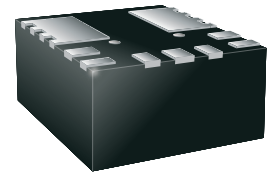
- Buck regulator power module with integrated shielded inductor
- 28V maximum input voltage
- 2.5A maximum output current
- SCP, OCP, OTP, OVP and UVLO protection
- 4.5mm x 4mm low profile QFN package
- Flip-Chip technology for improved thermal management
- Efficiency up to 91%

RECOM

DC/DC Converter

RPX-2.5

2.5 Amp QFN Package



Description

The RPX-2.5 is a buck converter with integrated inductor in a tiny 4.5mm x 4mm x 2mm thermally-enhanced QFN package (the smallest in its class). The input range is from 4.5 to 28VDC, allowing 5V, 12V or 24V supply voltages to be used. The output voltage can be set with two resistors in the range from 1.2V up to 6V. The output current is up to 2.5A and is fully protected against continuous short-circuits, output overcurrent or over-temperature faults. The enable pin features an internal pull-up current source, so will operate with open-drain, open-collector, logic gate or switched inputs (leave open if not used).

Selection Guide

| Part Number | Input Voltage Range [VDC] ⁽¹⁾ | Vout Adjust Range [VDC] ⁽¹⁾ | Output Current max. [A] | Efficiency max. [%] ⁽²⁾ | Max. Capacitive Load ⁽³⁾ [µF] |
|-------------|------------------------------------------|----------------------------------------|-------------------------|------------------------------------|------------------------------------------|
| RPX-2.5 | 4.5-28 | 1.2-6 | 2.5 | 91 | 500 |

Notes:

- Note1: Refer to **“Safe Operating Area”**
 Note2: Efficiency is tested at Vin= 12V, Iout= 1A, Vout= 5V
 Note3: Max. Cap Load is tested at nominal input and full resistive load

Model Numbering

RPX-2.5-CT

Output Current _____ Packaging ⁽⁴⁾

Notes:

Note4: add suffix “-CT” for bag packaging for more details refer to **“PACKAGING INFORMATION”** without suffix, standard tape and reel packaging

Specifications (measured @ ta= 25°C, 12Vin, 3.3Vout, full load unless otherwise stated, refer to test set up)

| ABSOLUTE MAXIMUM RATINGS | | | | |
|-----------------------------------------------------|------------------------------------------------------------------|---------|------|--------|
| Parameter | Condition | Min. | Typ. | Max. |
| Absolute Maximum Voltage ⁽⁵⁾ | Vin | -0.3VDC | | 30VDC |
| | CTRL, FB | -0.3VDC | | 7VDC |
| | SW | -0.3VDC | | 30VDC |
| | SW transient | -5VDC | | 30VDC |
| | Vout | -0.3VDC | | 7VDC |
| Shock | according to MIL-STD-883D, method 2002.3; 1ms, 1/2 sine, mounted | | | 1500G |
| Vibration | according to MIL-STD-883D, method 2007.7; 20Hz-2kHz | | | 20G |
| Operating IC Junction Temperature (T _J) | | -40°C | | +125°C |
| Operating Ambient Temperature (T _{AMB}) | | -40°C | | +85°C |
| Storage Temperature (T _{STO}) | | -55°C | | +150°C |

Notes:

Note5: Stresses beyond those listed under absolute maximum ratings can cause permanent damage to the device. (Values are at non-operating)



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Specifications (measured @ $t_a = 25^\circ\text{C}$, 12V_{in} , 3.3V_{out} , full load unless otherwise stated, refer to test set up)

OPERATING RATINGS

| Parameter | Condition | Min. | Typ. | Max. |
|---------------------------------------------------------------|----------------------------------------------|-----------------------|-------------------|---------------------|
| Input Voltage Range | | 4.5VDC ⁽⁶⁾ | | 28VDC |
| Under Voltage Lockout (UVLO) (default setting) ⁽⁷⁾ | DC-DC ON | 3.8VDC | 4.1VDC | 4.4VDC |
| | DC-DC OFF | 3.3VDC | 3.6VDC | 3.9VDC |
| Output Voltage Adjust Range | refer to "OUTPUT VOLTAGE SETTING" | 1.2VDC | | 6VDC |
| CTRL Voltage Range | | 0VDC | | 6VDC |
| CTRL ON/OFF Thresholds | DC-DC ON (or open) | | 1.21VDC | 1.28VDC |
| | DC-DC OFF (or short to GND) | 1.1VDC | 1.19VDC | |
| Input Current of CTRL Pin | $V_{\text{CTRL}} = 1.5\text{VDC}$ (DC-DC ON) | | 1.6 μA | |
| | $V_{\text{CTRL}} = 1\text{VDC}$ (DC-DC OFF) | | 0.7 μA | |
| Standby Current | DC-DC OFF | | 2 μA | |
| Output Current | | 0A | | 2.5A ⁽⁸⁾ |
| Start-up Time | power on | | 10ms | |
| | by using CTRL (without C_{OUT}) | | 6ms | |
| Rise-time | (internal soft start) | | 5ms | |
| Switching Frequency | | 550kHz | 750kHz | 1MHz |
| Output Ripple and Noise ⁽⁹⁾ | 20MHz BW | | 22mVp-p | |

Notes:

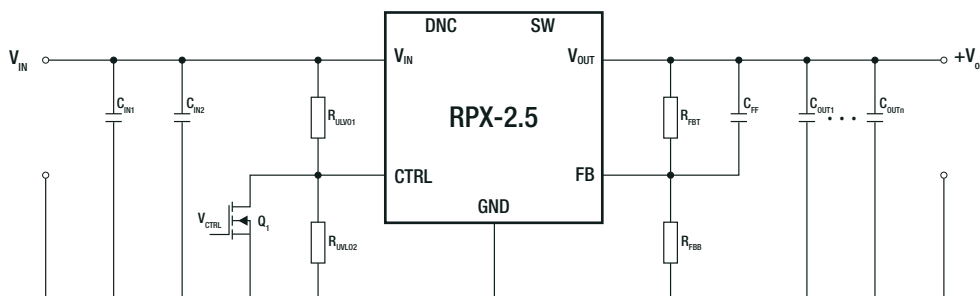
Note6: The minimum recommended input voltage is 4.5 V or ($V_{\text{OUT}} \times 1.3$), whichever is greater

Note7: Refer to **"UNDER VOLTAGE LOCKOUT SETTING"**

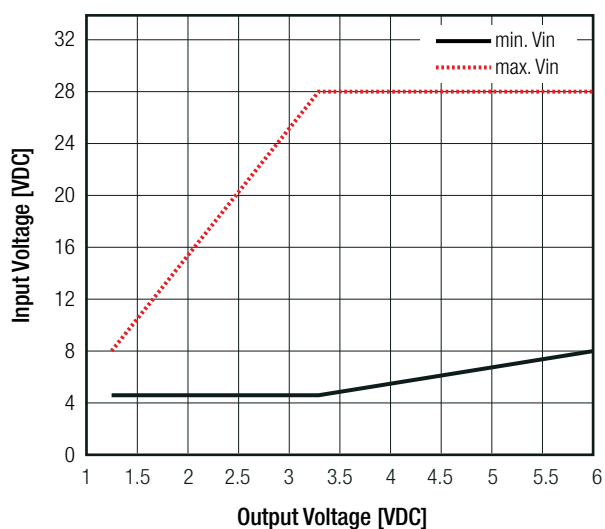
Note8: The maximum output current that the RPX can deliver is a function of input voltage, output voltage, and ambient temperature

Note9: Measurement with $C_{\text{IN}1} = 10\mu\text{F}$, 50V 1210 ceramic, $C_{\text{IN}2} = 100\mu\text{F}$, 35V electrolytic and $C_{\text{OUT}1,2} = 47\mu\text{F}$ 16V, ceramic capacitors

Test Set-up



Safe Operating Area



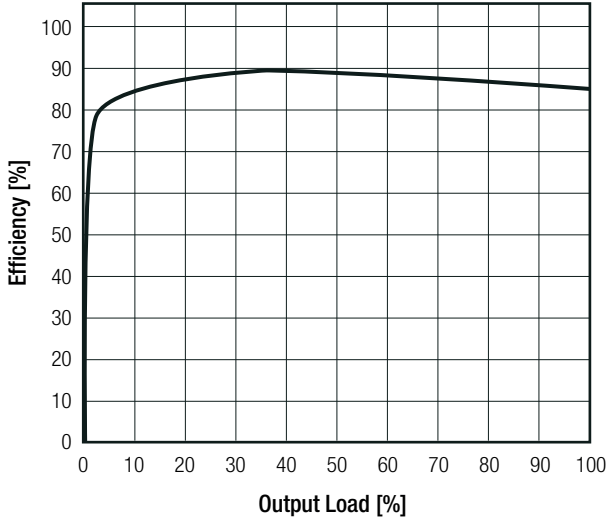
Typical operating conditions

| Nominal V_{in} | V_{out} | $I_{\text{out, max}}$ |
|-------------------------|------------------|-----------------------|
| 24VDC | 5VDC | 2.0A |
| 24VDC | 3.3VDC | 2.1A |
| 12VDC | 5VDC | 2.5A |
| 12VDC | 3.3VDC | 2.5A |
| 5VDC | 3.3VDC | 2.5A |
| 5VDC | 1.2VDC | 2.5A |

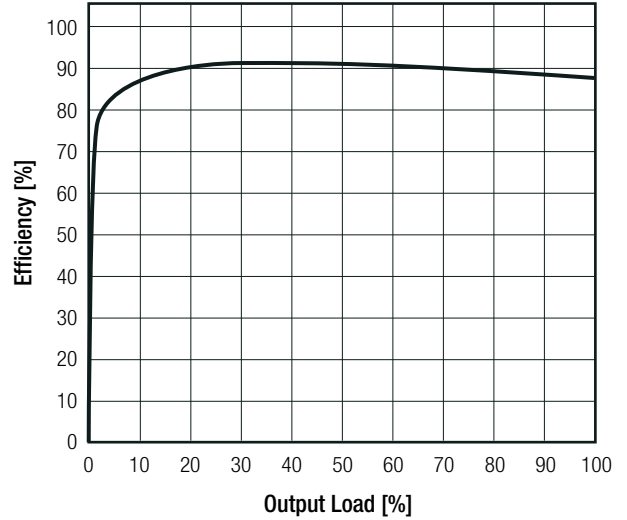
Specifications (measured @ $t_a = 25^\circ\text{C}$, 12V_{in} , 3.3V_{out} , full load and after warm-up unless otherwise stated, refer to test set up)

Efficiency vs. output current

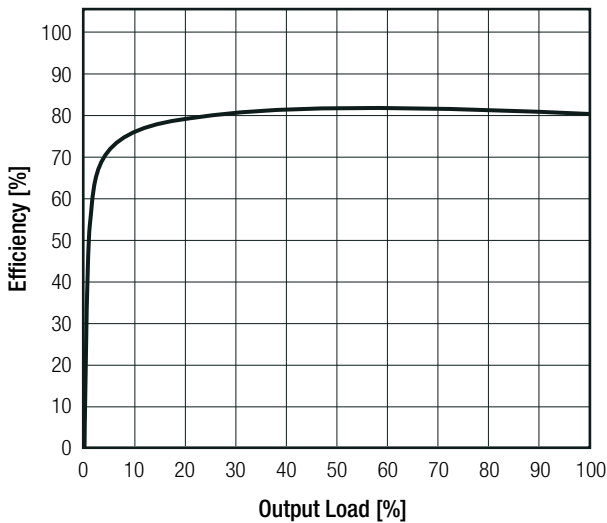
$V_{\text{out}} = 3.3\text{VDC}$, $V_{\text{in}} = 12\text{VDC}$ (2.5A max)



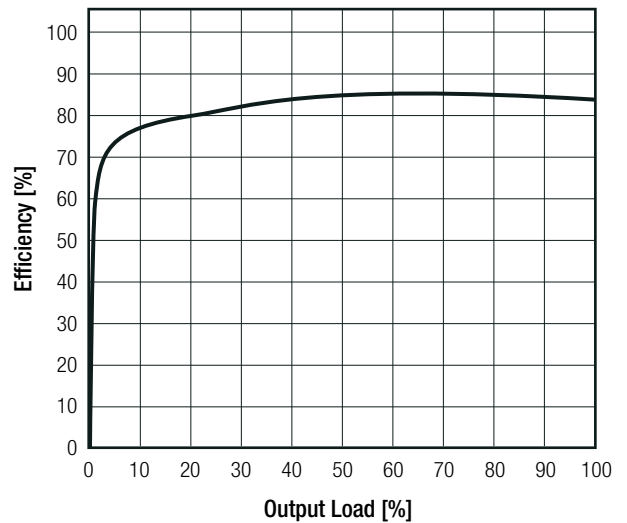
$V_{\text{out}} = 5\text{VDC}$, $V_{\text{in}} = 12\text{VDC}$ (2.5A max)



$V_{\text{out}} = 3.3\text{VDC}$, $V_{\text{in}} = 24\text{VDC}$ (2.0A max)



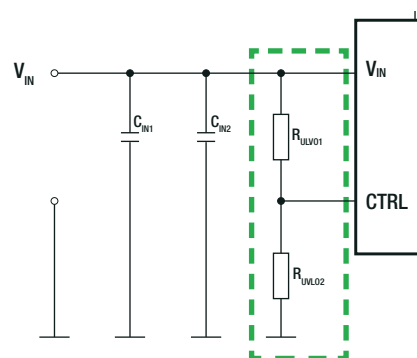
$V_{\text{out}} = 5\text{VDC}$, $V_{\text{in}} = 24\text{VDC}$ (2.1A max.)



UNDER VOLTAGE LOCKOUT SETTING

The RPX-2.5 features an internal UVLO circuit that disables the converter until the input voltage exceeds 4.1V typ. This threshold can be raised by adding an external resistor divider $R_{\text{UVLO}1}$ and $R_{\text{UVLO}2}$.

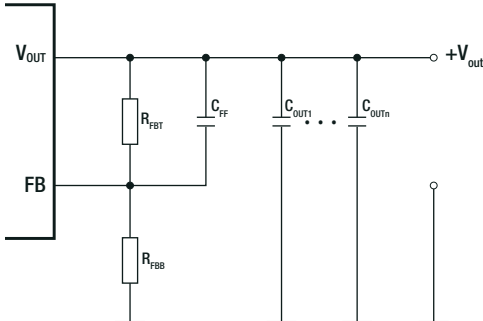
| Standard Resistor Values | | | | | |
|----------------------------------|------|------|------|------|------|
| $V_{\text{IN UVLO}}$ [VDC] | 4.5 | 10 | 15 | 18 | 20 |
| $R_{\text{UVLO}1}$ [k Ω] | 68.1 | 68.1 | 68.1 | 68.1 | 68.1 |
| $R_{\text{UVLO}2}$ [k Ω] | 25.5 | 9.53 | 6.04 | 4.99 | 4.42 |



Specifications (measured @ $t_a = 25^\circ\text{C}$, 12Vin, 3.3Vout, full load and after warm-up unless otherwise stated, refer to test set up)

OUTPUT VOLTAGE SETTING

The recommended value of R_{FBT} is $10\text{k}\Omega$. The values for trim resistors shown in trim tables below are according to standard E96 values; therefore, the specified voltage may slightly vary. For other output voltages, the value of the required R_{FBB} resistor can be calculated using below equation:



- $V_{out_{nom}}$ = nominal output voltage [VDC]
- $V_{out_{set}}$ = trimmed output voltage [VDC]
- V_{REF} = reference voltage (6VDC) [VDC]
- d = trim offset (0.6VDC) [VDC]
- R_{FBT} = Trim resistor ($10\text{k}\Omega$) [$\text{k}\Omega$]
- R_{FBB} = calculated trim resistor [$\text{k}\Omega$]

Calculation:

$$R_{FBB} = \left[\frac{V_{REF}}{V_{out_{set}} - d} \right]$$

Practical Example:

$$R_{FBB} = \left[\frac{6\text{VDC}}{3.3\text{VDC} - 0.6} \right] = 2.22\text{k}\Omega \quad R_{FBB} \text{ according to E96} \approx \underline{2.21\text{k}\Omega}$$

Resistor Table:

| | | | | | | | | | | | |
|---------------------------------|------|------|------|------|------|------|------|------|------|--------------|--------------|
| $V_{out_{set}} =$ | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2 | 2.1 | [VDC] |
| $R_{FBB} \text{ (E96)} \approx$ | 10k | 8k45 | 7k5 | 6k65 | 6k04 | 5k36 | 4k99 | 4k64 | 4k22 | 4k02 | [Ω] |
| $V_{out_{set}} =$ | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 2.8 | 2.9 | 3 | 3.1 | [VDC] |
| $R_{FBB} \text{ (E96)} \approx$ | 3k74 | 3k48 | 3k32 | 3k16 | 3k01 | 2k87 | 2k74 | 2k61 | 2k49 | 2k37 | [Ω] |
| $V_{out_{set}} =$ | 3.2 | 3.3 | 3.4 | 3.5 | 3.6 | 3.7 | 3.8 | 3.9 | 4 | 4.1 | [VDC] |
| $R_{FBB} \text{ (E96)} \approx$ | 2k32 | 2k21 | 2k15 | 2k05 | 2k | 1k96 | 1k87 | 1k82 | 1k74 | 1k69 | [Ω] |
| $V_{out_{set}} =$ | 4.2 | 4.3 | 4.4 | 4.5 | 4.6 | 4.7 | 4.8 | 4.9 | 5 | 5.1 | [VDC] |
| $R_{FBB} \text{ (E96)} \approx$ | 1k65 | 1k62 | 1k58 | 1k54 | 1k5 | 1k47 | 1k43 | 1k4 | 1k37 | 1k33 | [Ω] |
| $V_{out_{set}} =$ | 5.2 | 5.3 | 5.4 | 5.5 | 5.6 | 5.7 | 5.8 | 5.9 | 6 | [VDC] | |
| $R_{FBB} \text{ (E96)} \approx$ | 1k3 | 1k27 | 1k24 | 1k22 | 1k2 | 1k18 | 1k15 | 1k13 | 1k1 | [Ω] | |

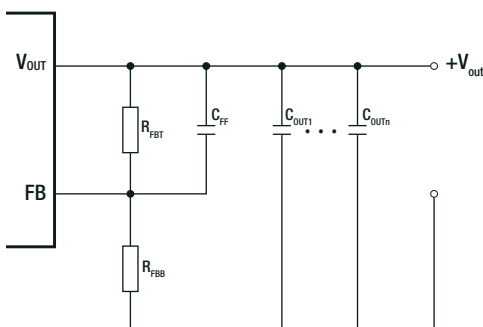
INPUT AND OUTPUT CAPACITOR

Input Capacitor

The RPX-2.5 requires a $10\mu\text{F}$ MLCC input capacitor for normal operation. For high transient load applications, an additional $47\mu\text{F}$ electrolytic capacitor connected in parallel is recommended, rated for a ripple current of 1.25A or higher.

Output Capacitor

The RPX-2.5 requires MLCC output capacitors for normal operation (see table). Transient load reaction time can be improved by adding a speedup capacitor, C_{FF} across R_{FBT} , but it is not required for normal operation or for output voltages below 2.5V.

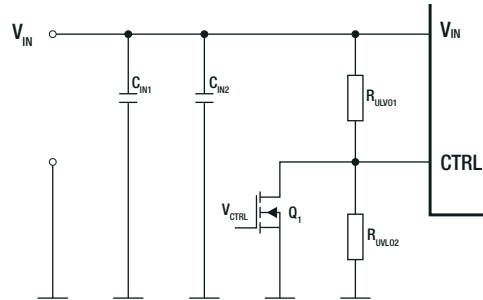


| Minimum output capacitance | | | |
|----------------------------|------|----------------------------------------------------|------------------------------------------|
| Set Output Voltage [VDC] | | Ceramic Capacitor (C_{OUTn}) [μF] | Feed Forward Capacitor (C_{FF}) [pF] |
| MIN | MAX | | |
| 1.2 | <1.5 | 188 (4 x $47\mu\text{F}$) | 330 |
| 1.5 | <2.5 | 141 (3 x $47\mu\text{F}$) | 220 |
| 2.5 | <3.3 | 94 (2 x $47\mu\text{F}$) | 100 |
| 3.3 | <5 | 94 (2 x $47\mu\text{F}$) | 100 |
| 5 | <6 | 47 | 100 |

Specifications (measured @ $t_a = 25^\circ\text{C}$, 12V_{in} , 3.3V_{out} , full load and after warm-up unless otherwise stated, refer to test set up)

CTRL ON/OFF

The external CTRL input can also be used to disable the converter by pulling the CTRL pin to ground. An internal pull-up current source allows an external switch, open-collector transistor, open-drain transistor or a 3.3V/5V logic gate to be used to drive the CTRL pin. The UVLO adjust and external CTRL functions can be combined.



REGULATIONS

| Parameter | Condition | Min. | Typ. | Max. |
|-------------------------|--------------------------------------------|----------|-------------------|----------|
| Feedback Voltage | no load | 0.581VDC | 0.596VDC | 0.611VDC |
| Temperature Coefficient | $I_{\text{OUT}} = 0.2\text{A}$ | | 0.003%/K | |
| Line Regulation | low line to high line | | $\pm 0.2\%$ | |
| Load Regulation | 5 - 100% load | | 0.2% | |
| | 0 - 5% load | | 0.5% | |
| Transient Response | 10 <-> 100% load step change recovery time | | 6ms | 200mV |
| | 25% <-> 75% load step change recovery time | | 125 μs | 100mV |

PROTECTIONS

| Parameter | Condition | Value |
|-----------------------------------|-------------------|---------------------------------------------------------------------------------------------|
| Short Circuit Protection (SCP) | | Hiccup Mode, auto recovery |
| Over Current Protection (OCP) | | 4.8A typ., hiccup mode |
| Over Temperature Protection (OTP) | internal junction | 165 $^\circ\text{C}$ typ., thermal shut down 10 $^\circ\text{C}$ typ. restart hysteresis |

ENVIRONMENTAL

| Parameter | Condition | Value | |
|-----------------------------------|------------------------------------------------|----------------------------------------|-----------------------------|
| ESD | human-body model (HBM), ANSI/ESDA/JEDEC JS-001 | $\pm 2.5\text{kV}$ | |
| | charged-device model (CDM), JEDEC JESD22-C101 | $\pm 1\text{kV}$ | |
| Moisture Sensitive Level | MSL peak temp. ⁽¹⁰⁾ | Level 3, 260 $^\circ\text{C}$, 168hrs | |
| Thermal Impedance ⁽¹¹⁾ | junction to T_{AMB} | 32.7K/W | |
| | junction to case (refer to tc point) | 2.2K/W | |
| | junction to board (refer to tb point) | 17K/W | |
| MTBF | according to TR-332, 50% stress G.B. | +25 $^\circ\text{C}$ | 400 x 10 ⁶ hours |
| | | +85 $^\circ\text{C}$ | 6 x 10 ⁶ hours |

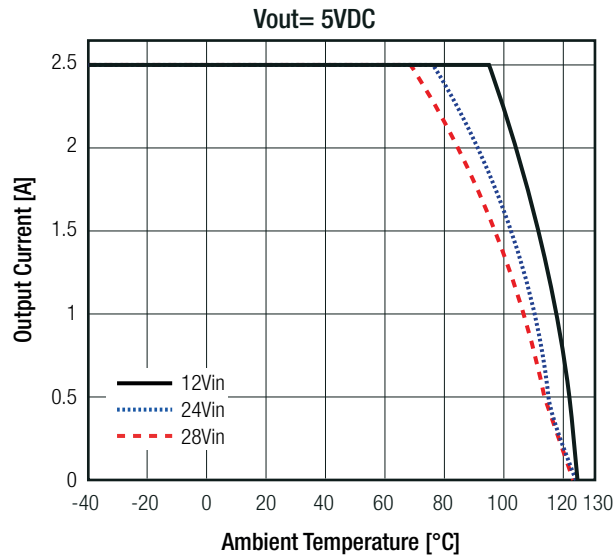
Notes:

Note10: The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature

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Specifications (measured @ $t_a = 25^\circ\text{C}$, 12Vin, 3.3Vout, full load and after warm-up unless otherwise stated, refer to test set up)

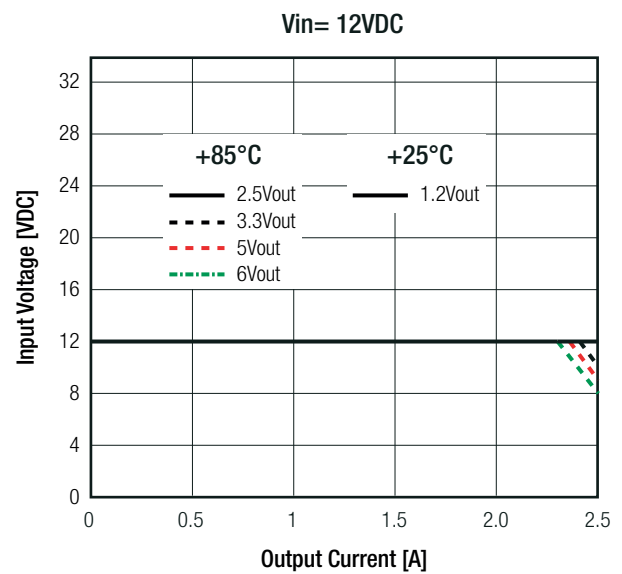
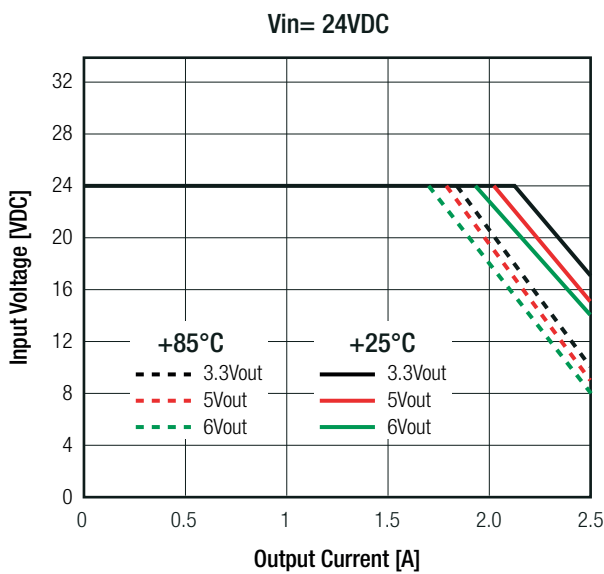
Thermal Derating ⁽¹¹⁾



Notes:

Note11: Tested with 54.0 x 85.6mm 2 layer PCB with 105µm copper

Input voltage vs. output current
(tested without additional test PCB)



SAFETY AND CERTIFICATIONS

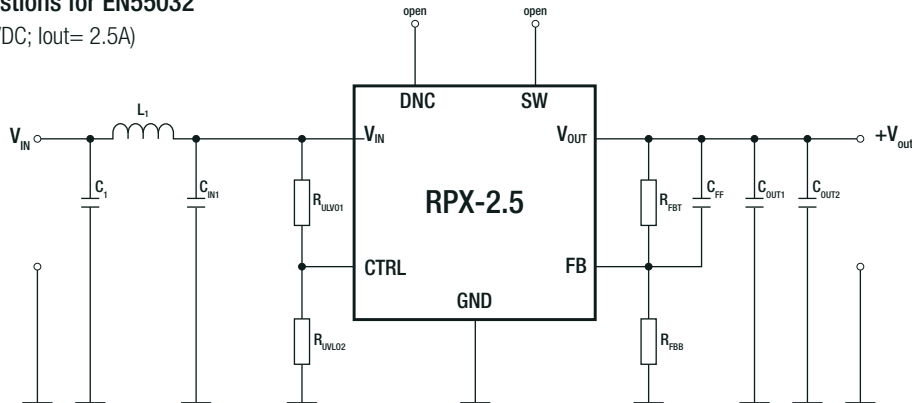
| | | |
|-------------------------------------------------------------------------------|---------------------------------|-----------------------------|
| Certificate Type (Safety) | Standard | |
| RoHS2 | RoHS 2011/65/EU + AM2015/863 | |
| EMC Compliance | Condition | Standard / Criterion |
| Electromagnetic compatibility of multimedia equipment - Emission requirements | refer to "EMC Filtering" | EN55032, Class B |

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Specifications (measured @ $t_a = 25^\circ\text{C}$, $V_{in} = 12\text{VDC}$, $V_{out} = 3.3\text{VDC}$, full load and after warm-up unless otherwise stated, refer to test set up)

EMC Filtering suggestions for EN55032

($V_{in} = 12\text{VDC}$; $V_{out} = 5\text{VDC}$; $I_{out} = 2.5\text{A}$)



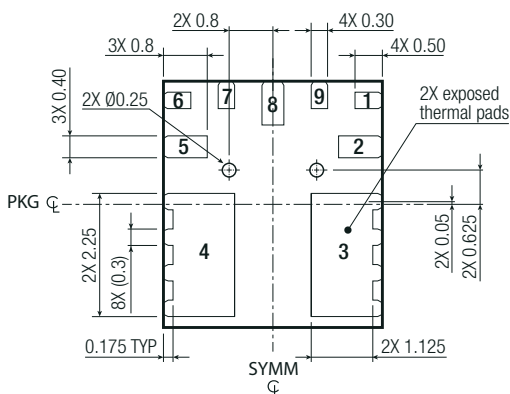
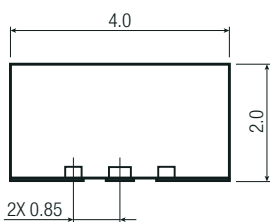
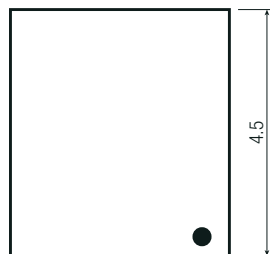
Component List Class B

| C1, CIN1 | L1 | COUT1,2 |
|----------------------------------|----------------------------------------------------------|----------------------------------|
| 10 μF , 50V; X7R 1210 | 18μH choke RLS-186 | 47 μF , 10V; X7R 1210 |

DIMENSION AND PHYSICAL CHARACTERISTICS

| Parameter | Type | Value |
|-------------------|------|-------------------|
| Material | case | plastic, UL94 V-0 |
| Dimension (LxWxH) | | 4.1 x 4.6 x 2.1mm |
| Weight | | 107mg typ. |

Dimension Drawing (mm)

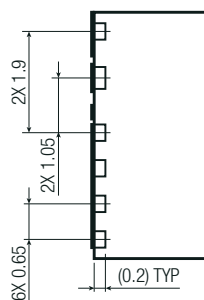


Pad Information

| Pad # | Function | Description |
|-------|----------|-----------------------------------------------------------------------------------------------|
| 1 | FB | Feedback Input. Used to set the output voltage between 1.2V and 6V |
| 2 | VIN | Input Voltage. Connect external bypass capacitors between this pin and GND close to the pins |
| 3 | VOUT | Output Voltage. Connect external bypass capacitors between this pin and GND close to the pins |
| 4, 5 | SW | Switch node. Do not connect |
| 6, 7 | DNC | Do not connect. Must be soldered to an isolated pad |
| 8 | GND | Ground pin. Connect this pin to the power ground plane on the PCB |
| 9 | CTRL | CTRL pin. Float this pin when not used |

Tolerances: $x.x = \pm 0.1\text{mm}$
 $x.xx / x.xxx = \pm 0.05\text{mm}$

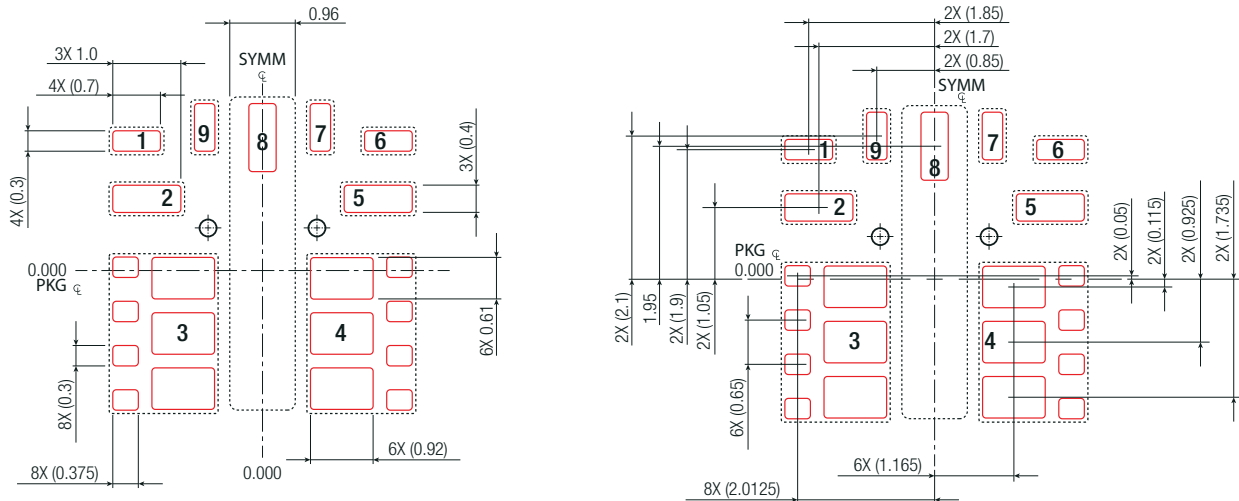
Dimensioning and tolerancing according to ASME Y14.5



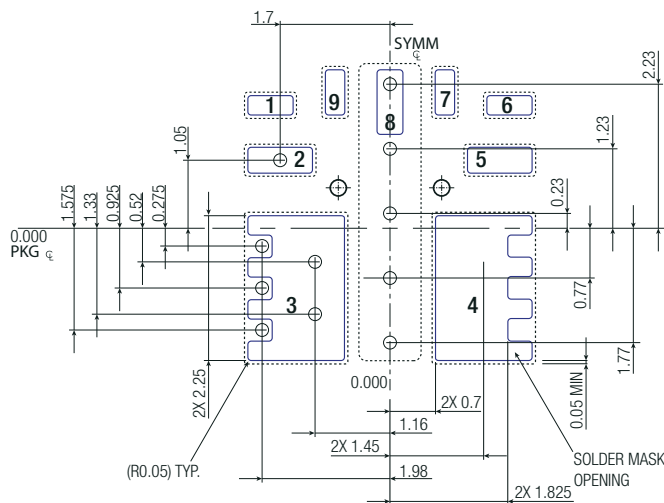
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Specifications (measured @ $t_a = 25^\circ\text{C}$, 12Vin, 3.3Vout, full load and after warm-up unless otherwise stated, refer to test set up)

Recommended Stencil (Top View)



Recommended Footprint Details (Top View)



Thermal pads are required to meet full specifications. Vias must be filled or plugged for optimum thermal performance.

For more information about the soldering profile, visit our website and download our [App Notes](#).

PACKAGING INFORMATION

| Parameter | Type | Value |
|-----------------------------|------------------------------|------------------------|
| Packaging Dimension (LxWxH) | reel (diameter + width) | Ø330.0 + 12.4mm height |
| | tape and reel (carton) | 336.0 x 336.0 x 48.0mm |
| Packaging Quantity | moisture barrier bag ("-CT") | 100.0 x 100.0 x 30mm |
| | tape and reel | 250pcs |
| Tape Width | moisture barrier bag ("-CT") | 10pcs |
| Storage Temperature Range | | 12mm |
| Storage Humidity | | -55°C to +125°C |
| ESD Sensitivity Level | non-condensing | 95% RH max. |
| Moisture Sensitivity Level | HBM | Class 2 |
| | JEDEC J-STD-020E | MSL3 |

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