1.5MHz, 600mA, High Efficiency PWM Step-Down DC/DC Converter

General Description

The RT8008 is a high-efficiency pulse-width-modulated (PWM) step-down DC-DC converter. Capable of delivering 600mA output current over a wide input voltage range from 2.2 to 5.5V, the RT8008 is ideally suited for portable electronic devices that are powered from 1-cell Li-ion battery or from other power sources within the range such as cellular phones, PDAs and handy-terminals.

Two operational modes are available: PSM/PWM/ Low-Dropout autoswitch and shut-down modes. Internal synchronous rectifier with low $R_{DS(ON)}$ dramatically reduces conduction loss at PWM mode. No external Schottky diode is required in practical application. The RT8008 automatically turns off the synchronous rectifier while the inductor current is low and enters discontinuous PWM mode. This can increase efficiency at light load condition.

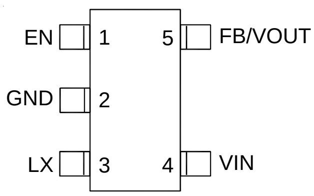
The RT8008 enters PSM (Pulse-Skipping Mode) at extremely light load condition. The equivalent switching frequency is reduced to increase the efficiency in PSM.

The RT8008 enters Low-Dropout mode when normal PWM cannot provide regulated output voltage by continuously turning on the upper P-MOSFET. RT8008 enter shutdown mode and consumes less than 0.1uA when EN pin is pulled low.

The switching ripple is easily smoothed-out by small package filtering elements due to a fixed operation frequency of 1.5MHz. This along with small SOT-23-5 and TSOT-23-5 package provides small PCB area application. Other features include soft start, lower internal reference voltage with 2% accuracy, over temperature protection, and over current protection.

Pin Configurations

(TOP VIEW)



SOT-23-5/TSOT-23-5

Features

- **+2.2V to +5.5V Input Range**
- **Adjustable Output From 0.6V to V_{IN}**
- **1.0V, 1.2V, 1.5V, 1.8V, 2.5V and 3.3V Fixed/ Adjustable Output Voltage**
- **600mA Output Current**
- **95% Efficiency**
- **No Schottky Diode Required**
- **50uA Quiescent Current**
- **1.5MHz Fixed-Frequency PWM Operation**
- **Pulse-skipping Mode Operation During Light load**
- **Small SOT-23-5 and TSOT-23-5 Package**
- **RoHS Compliant and 100% Lead (Pb)-Free**

Applications

- Cellular Telephones
- Personal Information Appliances
- Wireless and DSL Modems
- MP3 Players
- Portable Instruments

Ordering Information

RT8008(-□□)□□

Package Type
B : SOT-23-5
J5 : TSOT-23-5

Operating Temperature Range
C : Commercial Standard
P : Pb Free with Commercial Standard

Output Voltage
Default : Adjustable
10 : 1.0V
12 : 1.2V
15 : 1.5V
18 : 1.8V
25 : 2.5V
33 : 3.3V

Note :
RichTek Pb-free products are :
- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.
- 100% matte tin (Sn) plating.

Typical Application Circuit

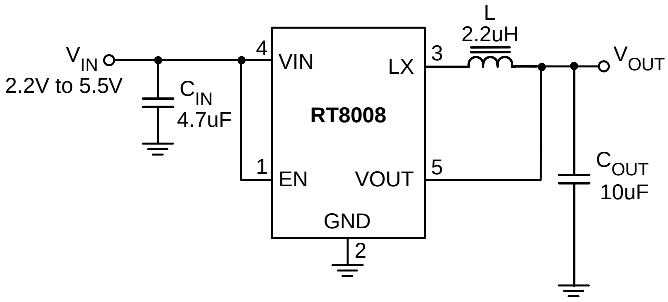
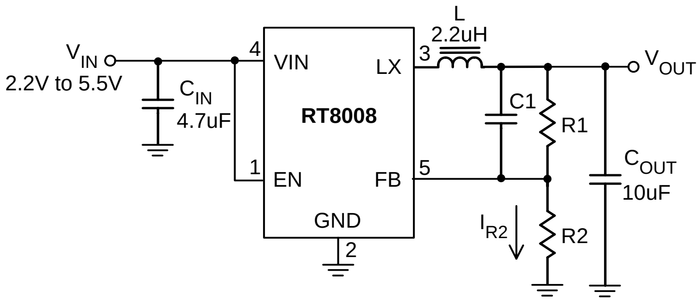


Figure 1. Fixed Voltage Regulator



$$V_{OUT} = V_{REF} \times \left(1 + \frac{R1}{R2}\right)$$

with R2 = 300kΩ to 60kΩ so the I_{R2} = 2μA to 10μA,

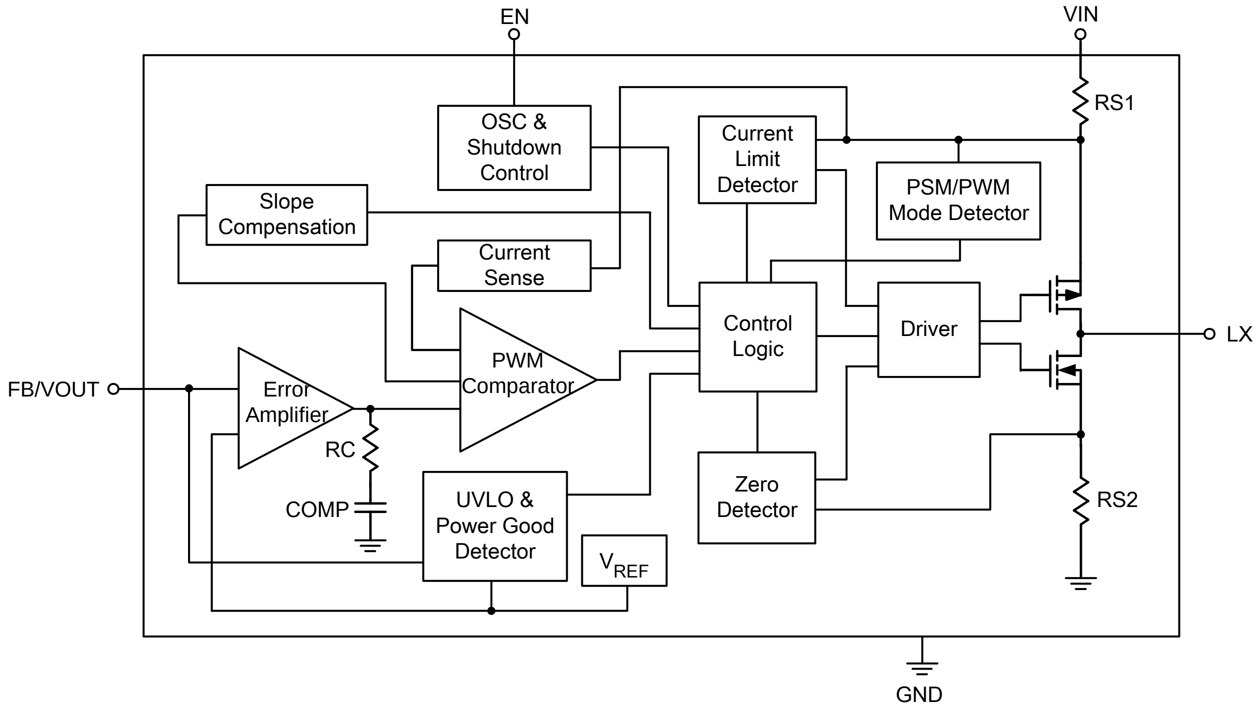
and (R1 x C1) should be in the range between 3×10^{-6} and 6×10^{-6}ΩF for component selection.

Figure 2. Adjustable Voltage Regulator

Functional Pin Description

Pin Number	Pin Name	Pin Function
1	EN	Chip Enable (Active High)
2	GND	Ground
3	LX	Pin for Switching
4	VIN	Power Input
5	FB/VOUT	Feedback Input Pin

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage ---------- 6.5V
- Enable, FB Voltage ---------- V_{IN} + 0.6V
- Power Dissipation, P_D @ T_A = 25°C
  SOT-23-5, TSOT-23-5 ---------- 0.4W
- Package Thermal Resistance (Note 4)
  SOT-23-5, TSOT-23-5, θ_{JA} ---------- 250°C/W
  SOT-23-5, TSOT-23-5, θ_{JC} ---------- 130°C/W
- Junction Temperature Range ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- −65°C to 150°C
- ESD Susceptibility (Note 2)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 3)

- Supply Input Voltage ---------- 2.2V to 5.5V
- Operating Ambient Temperature Range ---------- −40°C to 85°C
- Operating Junction Temperature Range ---------- −40°C to 125°C

Electrical Characteristics

(V_{IN} = 3.6V, V_{OUT} = 2.5V, V_{REF} = 0.6V, L = 2.2μH, C_{IN} = 4.7μF, C_{OUT} = 10μF, T_A = 25°C, I_{MAX} = 600mA unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Input Voltage Range	V_{IN}		2.2	--	5.5	V
Quiescent Current	I_Q	I_{OUT} = 0mA, V_{FB} = V_{REF} + 5%	--	50	100	μA
Shutdown Current	$I_{Q(SD)}$	EN = GND	--	0.1	1	μA
Reference Voltage	V_{REF}	For adjustable output voltage	0.588	0.6	0.612	V
Adjustable Output Range	V_{OUT}		V_{REF}	--	V_{IN}	V
Output Voltage Accuracy	ΔV_{OUT}	V_{IN} = 2.2 to 5.5V, V_{OUT} = 1.0V 0mA < I_{OUT} < 600mA	-3	--	+3	%
	ΔV_{OUT}	V_{IN} = 2.2 to 5.5V, V_{OUT} = 1.2V 0mA < I_{OUT} < 600mA	-3	--	+3	%
	ΔV_{OUT}	V_{IN} = 2.2 to 5.5V, V_{OUT} = 1.5V 0mA < I_{OUT} < 600mA	-3	--	+3	%
	ΔV_{OUT}	V_{IN} = 2.2 to 5.5V, V_{OUT} = 1.8V 0mA < I_{OUT} < 600mA	-3	--	+3	%
	ΔV_{OUT}	V_{IN} = 2.8 to 5.5V, V_{OUT} = 2.5V 0mA < I_{OUT} < 600mA	-3	--	+3	%
	ΔV_{OUT}	V_{IN} = 3.5 to 5.5V, V_{OUT} = 3.3V 0mA < I_{OUT} < 600mA	-3	--	+3	%
	ΔV_{OUT}	V_{IN} = V_{OUT} + 0.2V to 5.5V 0mA < I_{OUT} < 600mA	-3	--	+3	%
FB Input Current	I_{FB}	V_{FB} = V_{IN}	-50	--	50	nA

To be continued

Parameter	Symbol	Test Conditions		Min	Typ	Max	Units
PMOSFET R_{ON}	$P_{RDS(ON)}$	I_{OUT} = 200mA	V_{IN} = 3.6V	--	0.35	--	Ω
			V_{IN} = 2.5V	--	0.45	--	
NMOSFET R_{ON}	$N_{RDS(ON)}$	I_{OUT} = 200mA	V_{IN} = 3.6V	--	0.30	--	Ω
			V_{IN} = 2.5V	--	0.40	--	
P-Channel Current Limit	$I_{P(LM)}$	V_{IN} = 2.2 to 5.5 V		0.8	--	1.8	A
EN High-Level Input Voltage	V_{ENH}	V_{IN} = 2.2V to 5.5V		1.5	--	--	V
EN Low-Level Input Voltage	V_{ENL}	V_{IN} = 2.2V to 5.5V		--	--	0.4	V
Undervoltage Lock Out threshold				--	1.8	--	V
Hysteresis				--	0.1	--	V
Oscillator Frequency	f_{OSC}	V_{IN} = 3.6V, I_{OUT} = 100mA		1.2	1.5	1.8	MHz
Thermal Shutdown Temperature	T_{SD}			--	160	--	°C
Min. On Time				--	50	--	ns
Max. Duty Cycle				100	--	--	%
LX Leakage Current		V_{IN} = 3.6V, V_{LX} = 0V or V_{LX} = 3.6V		-1	--	1	μA

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

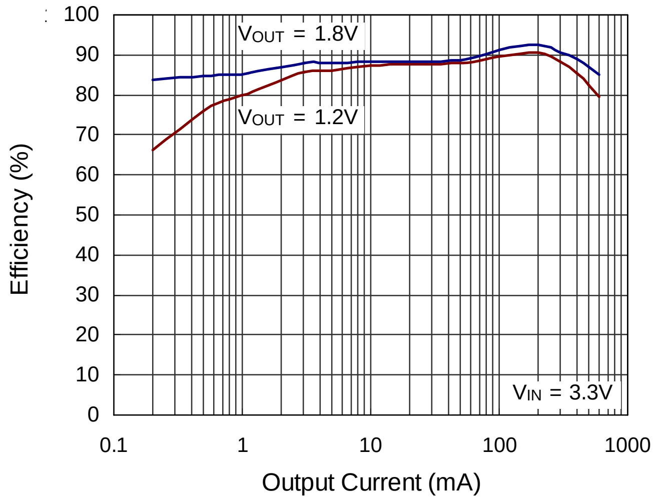
Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. The device is not guaranteed to function outside its operating conditions.

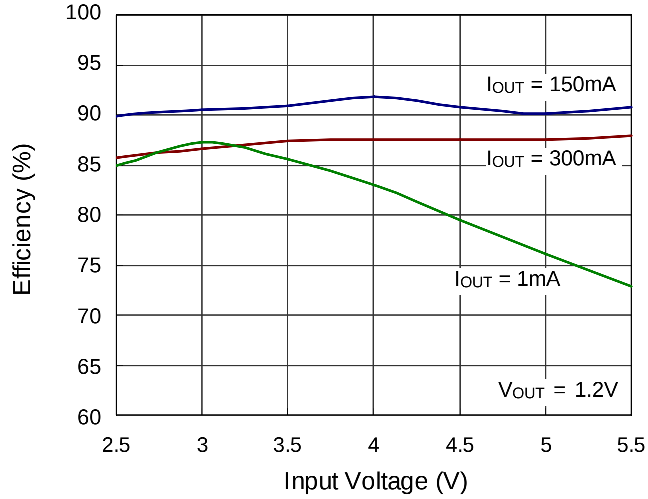
Note 4. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Pin 2 of SOT-23-5/TSOT-23-5 packages is the case position for θ_{JC} measurement.

Typical Operating Characteristics

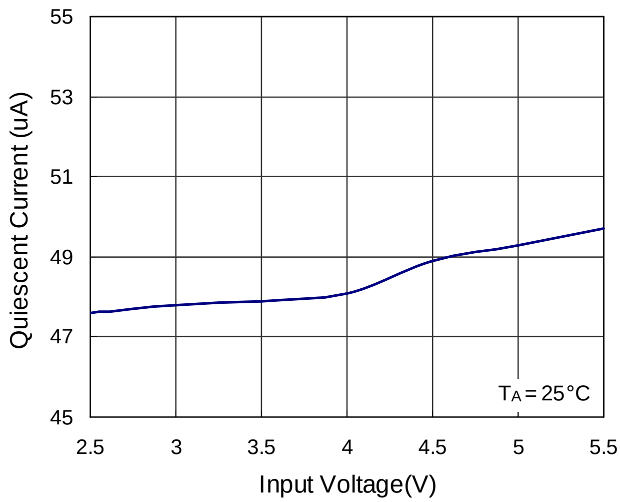
Efficiency vs. Output Current



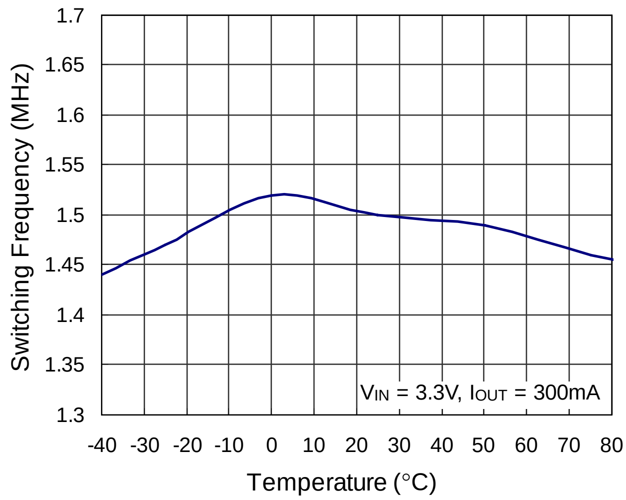
Efficiency vs. Input Voltage



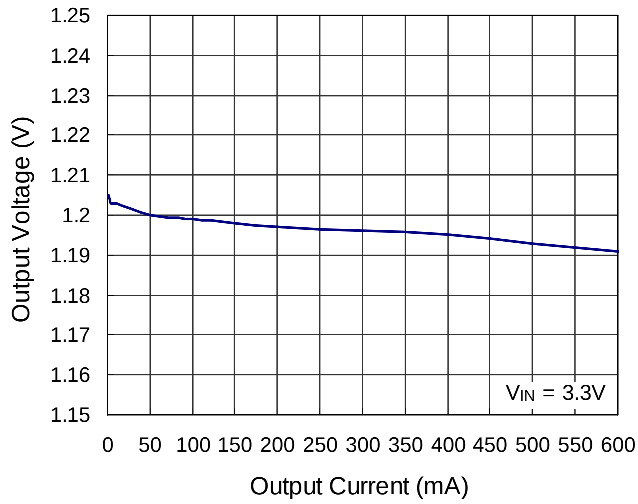
Quiescent Current vs. Input Voltage



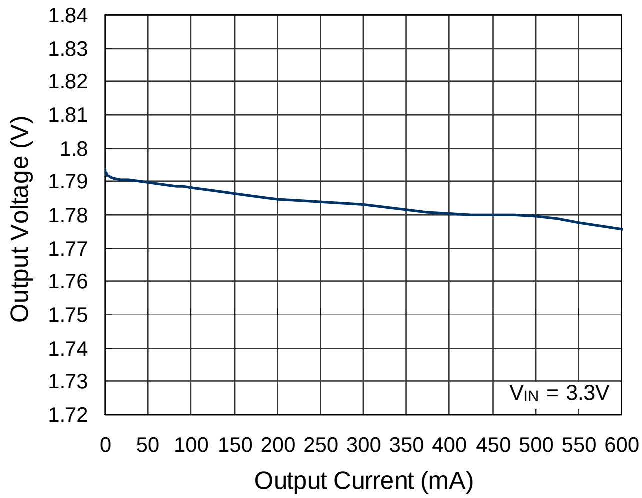
Switching Frequency vs. Temperature



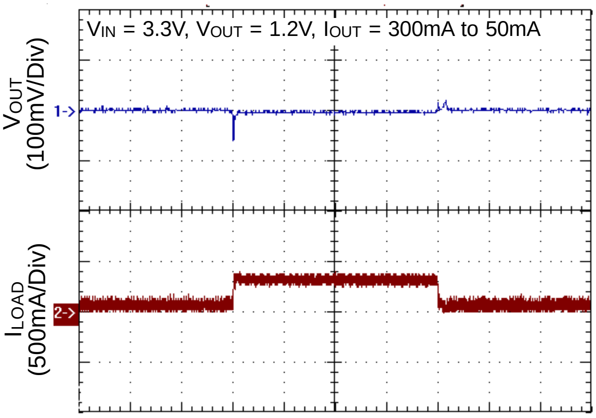
Output Voltage vs. Output Current



Output Voltage vs. Output Current

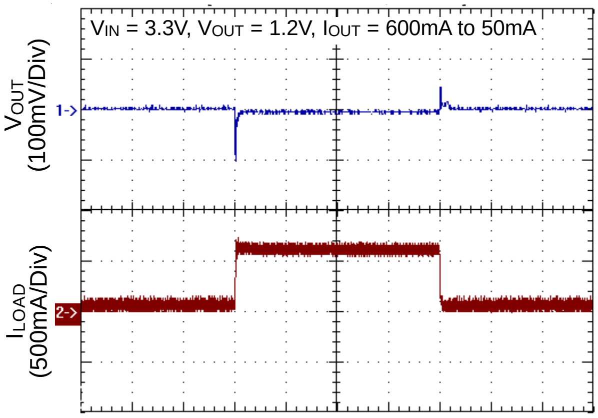


Load Transient Response



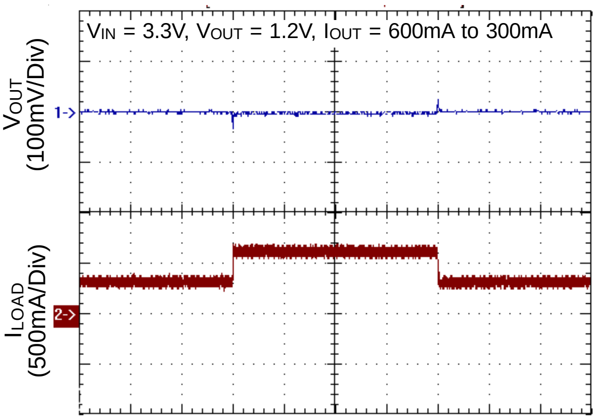
Time (250μs/Div)

Load Transient Response



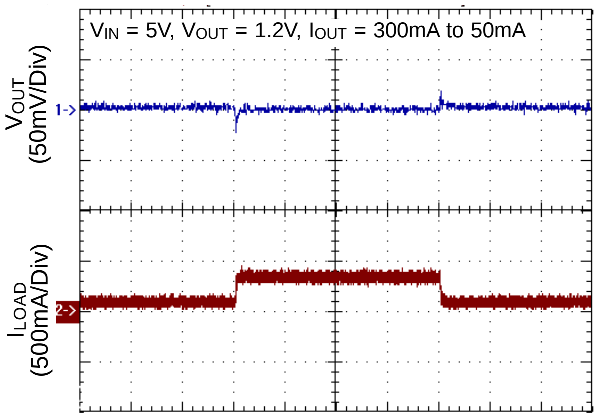
Time (250μs/Div)

Load Transient Response



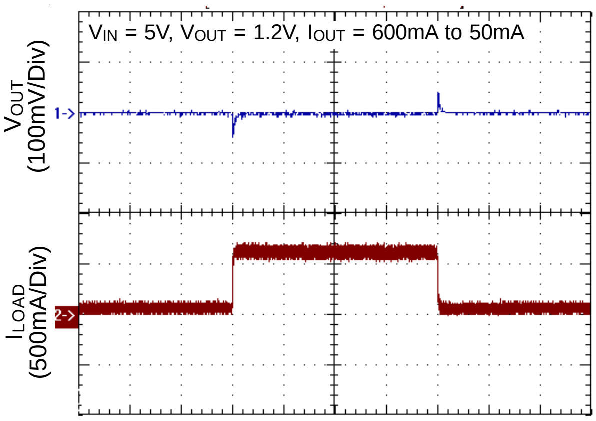
Time (250μs/Div)

Load Transient Response



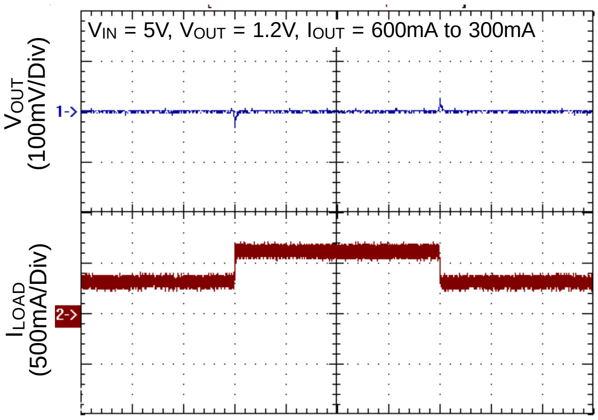
Time (250μs/Div)

Load Transient Response



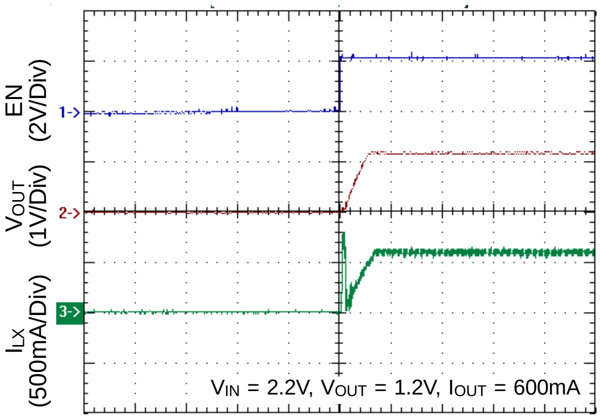
Time (250μs/Div)

Load Transient Response



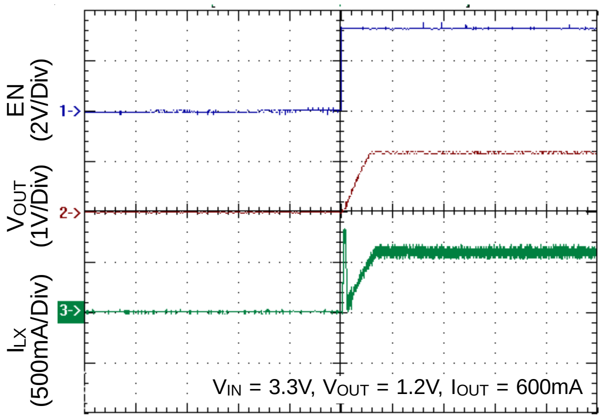
Time (250μs/Div)

Start-Up



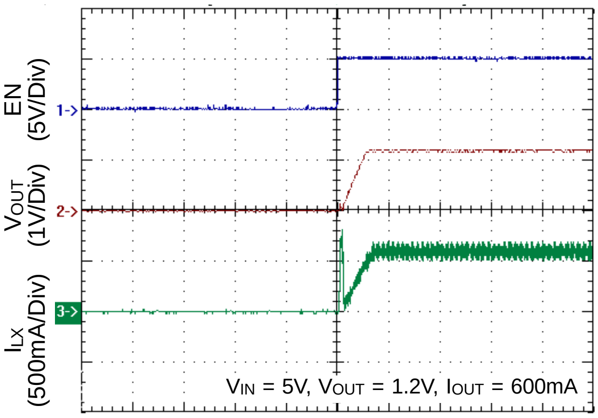
Time (1ms/Div)

Start-Up



Time (1ms/Div)

Start-Up



Time (1ms/Div)

Applications Information

Thermal Considerations

The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junction to ambient. The maximum power dissipation can be calculated by following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

Where $T_{J(MAX)}$ is the maximum operation junction temperature 125°C, T_A is the ambient temperature and the θ_{JA} is the junction to ambient thermal resistance.

For recommended operating conditions specification of RT8008 DC/DC converter, where $T_{J (MAX)}$ is the maximum junction temperature of the die (125°C) and T_A is the maximum ambient temperature. The junction to ambient thermal resistance θ_{JA} is layout dependent. For SOT-23-5/TSOT-23-5 packages, the thermal resistance θ_{JA} is 250°C/W on the standard JEDEC 51-3 single-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by following formula :

$P_{D(MAX)}$ = (125°C - 25°C) / 250 = 0.4 W for SOT-23-5/TSOT-23-5 packages

The maximum power dissipation depends on operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance θ_{JA}. For RT8008 packages, the Figure 1 of derating curves allows the designer to see the effect of rising ambient temperature on the maximum power allowed.

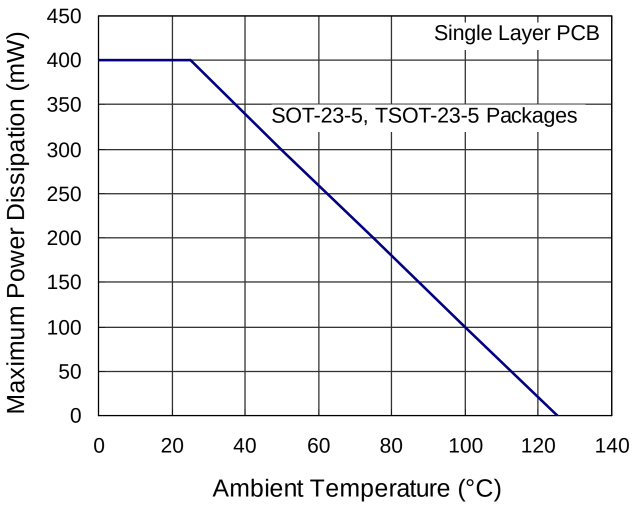


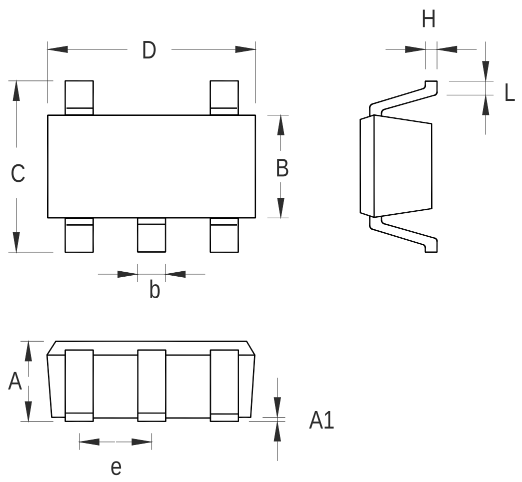
Figure 1. Derating Curves for RT8008 Package

The value of junction to case thermal resistance θ_{JC} is popular for users. This thermal parameter is convenient for users to estimate the internal junction operated temperature of packages while IC operating. It's independent of PCB layout, the surroundings airflow effects and temperature difference between junction to ambient. The operated junction temperature can be calculated by following formula :

$T_J = T_C + P_D \times \theta_{JC}$

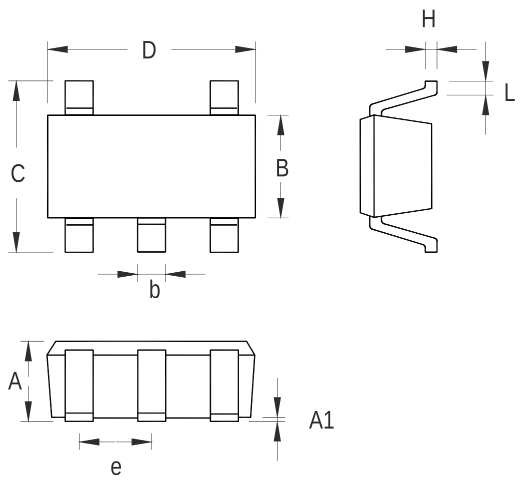
Where T_C is the package case (Pin 2 of package leads) temperature measured by thermal sensor, P_D is the power dissipation defined by user's function and the θ_{JC} is the junction to case thermal resistance provided by IC manufacturer. Therefore it's easy to estimate the junction temperature by any condition.

Outline Dimension



<table>
<tr><th rowspan="2">Symbol</th><th colspan="2">Dimensions In Millimeters</th><th colspan="2">Dimensions In Inches</th></tr>
<tr><th>Min</th><th>Max</th><th>Min</th><th>Max</th></tr>
<tr><td>A</td><td>0.889</td><td>1.295</td><td>0.035</td><td>0.051</td></tr>
<tr><td>A1</td><td>0.000</td><td>0.152</td><td>0.000</td><td>0.006</td></tr>
<tr><td>B</td><td>1.397</td><td>1.803</td><td>0.055</td><td>0.071</td></tr>
<tr><td>b</td><td>0.356</td><td>0.559</td><td>0.014</td><td>0.022</td></tr>
<tr><td>C</td><td>2.591</td><td>2.997</td><td>0.102</td><td>0.118</td></tr>
<tr><td>D</td><td>2.692</td><td>3.099</td><td>0.106</td><td>0.122</td></tr>
<tr><td>e</td><td>0.838</td><td>1.041</td><td>0.033</td><td>0.041</td></tr>
<tr><td>H</td><td>0.080</td><td>0.254</td><td>0.003</td><td>0.010</td></tr>
<tr><td>L</td><td>0.300</td><td>0.610</td><td>0.012</td><td>0.024</td></tr>
</table>

SOT-23-5 Surface Mount Package



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	1.000	0.028	0.039
A1	0.000	0.100	0.000	0.004
B	1.397	1.803	0.055	0.071
b	0.300	0.559	0.012	0.022
C	2.591	3.000	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

TSOT-23-5 Surface Mount Package

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