300mA, Ultra-Low Dropout, Ultra-Fast CMOS LDO Regulator

General Description

The RT9187A is a high-performance, 300mA LDO regulator, offering extremely high PSRR and ultra-low dropout. Ideal for portable RF and wireless applications with demanding performance and space requirements.

A noise reduction pin is also available for further reduction of output noise. Regulator ground current increases only slightly in dropout, further prolonging the battery life. The RT9187A also works with low-ESR ceramic capacitors, reducing the amount of board space necessary for power applications, critical in hand-held wireless devices.

The RT9187A consumes less than 0.1μA in shutdown mode and has fast turn-on time less than 100μs. The other features include ultra-low dropout voltage, high output accuracy, current limiting protection, and high ripple rejection ratio. Available in the SOT-23-5 and VDFN-6L 2x2 package.

Ordering Information

RT9187A-□□□□

- Package Type
  - B: SOT-23-5
  - QV : VDFN-6L 2x2 (V-Type)
- Lead Plating System
  - P : Pb Free
- Fixed Output Voltage Code
  - 27 : 2.7V
  - 28 : 2.8V
  - 2G : 2.75V

Note :

Richtek 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.

Marking Information

For marking information, contact our sales representative directly or through a Richtek distributor located in your area.

Features

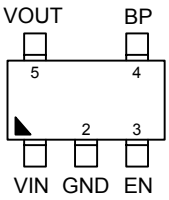
- **Ultra-Low-Noise for RF Application**
- **Ultra-Fast Response in Line/Load Transient**
- **Quick Start-Up (Typically 40μs)**
- **<0.1μA Standby Current When Shutdown**
- **Low Dropout : 75mV @ 300mA**
- **Wide Operating Voltage Ranges : 2.5V to 5.5V**
- **TTL-Logic-Controlled Shutdown Input**
- **Low Temperature Coefficient**
- **Current Limiting Protection**
- **Thermal Shutdown Protection**
- **Only 1μF Output Capacitor Required for Stability**
- **High Power Supply Rejection Ratio**
- **RoHS Compliant and 100% Lead (Pb)-Free**

Applications

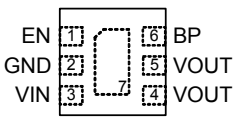
- CDMA/GSM Cellular Handsets
- Portable Information Appliances
- Battery-Powered Equipment
- Laptop, Palmtops, Notebook Computers
- Hand-Held Instruments
- Mini PCI & PCI-Express Cards
- PCMCIA & New Cards

Pin Configurations

(TOP VIEW)

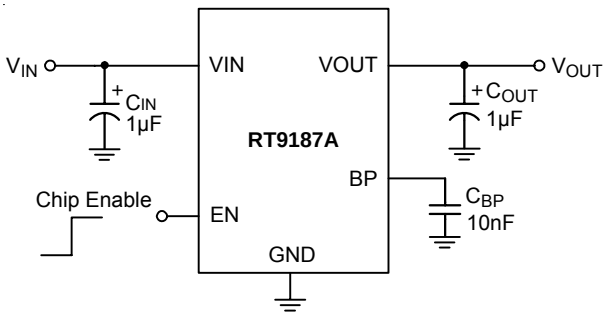


SOT-23-5



VDFN-6L 2x2

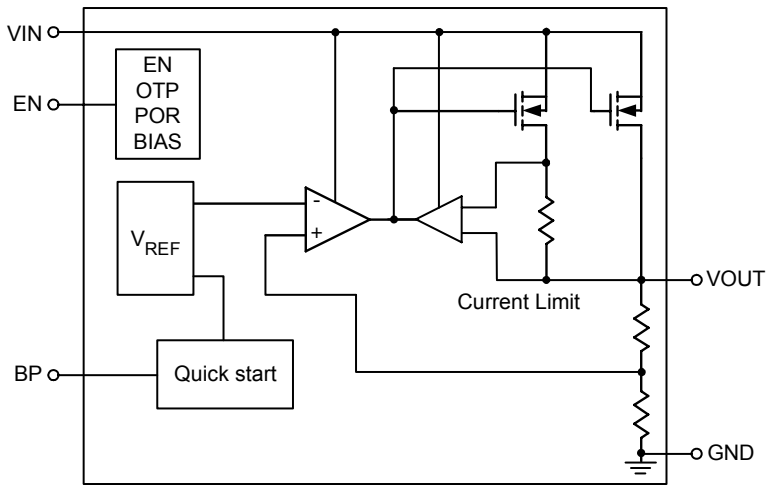
Typical Application Circuit



Functional Pin Description

RT9187A-□□□B	RT9187A-□□PQV	Pin Name	Pin Function
1	3	VIN	Supply Input
2	2	GND	Ground
3	1	EN	Enable Input Logic, Active High. When the EN goes to a logic low, the device is in shutdown mode.
4	--	BP	Noise Reduction. Connecting a 10nF capacitor to GND to reduce output noise.
--	6	BP	
5	4, 5	VOUT	Regulator Output
--	Exposed Pad	NC	No Internal Connection.

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage ---------- 6V
- EN Input Voltage ---------- 6V
- Power Dissipation, P_D @ T_A = 25°C
  - SOT-23-5 ---------- 0.455W
  - VDFN-6L 2x2 ---------- 0.606W
- Package Thermal Resistance (Note 2)
  - SOT-23-5, θ_{JA} ---------- 220°C/W
  - VDFN-6L 2x2, θ_{JA} ---------- 165°C/W
  - VDFN-6L 2x2, θ_{JC} ---------- 20°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  - HBM ---------- 2kV
  - MM ---------- 200V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage ---------- 2.5V to 5.5V
- EN Input Voltage ---------- 0V to 5.5V
- Operation Junction Temperature Range ---------- –40°C to 125°C
- Operation Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 3V, V_{OUT} = 2.7V, V_{EN} = V_{IN}, C_{IN} = C_{OUT} = 1µF (Ceramic) & C_{BP} = 10nF, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage Accuracy		ΔV_{OUT}	I_{OUT} = 10mA	–2	0	+2	%
Output Noise Voltage		eNo	BW = 10Hz to 100kHz I_{OUT} = 1mA, C_{OUT} = 1µF C_{BP} = 100nF	--	40	--	µV
Quiescent Current	(Note 5)	I_Q	I_{OUT} = 0mA, Enable	--	210	250	µA
Standby Current	(Note 6)	I_{STBY}	V_{IN} = 5.5V, Shutdown	--	0.1	1	µA
Current Limit		I_{LIM}	R_{LOAD} = 1Ω	2	2.5	3	A
Dropout Voltage	(Note 7)	V_{DROP}	I_{OUT} = 250mA (Note 8)	--	60	100	mV
			I_{OUT} = 500mA	--	120	180	
Load Regulation	(Note 9)	ΔV_{LOAD}	10mA < I_{OUT} < 500mA	--	0.1	0.2	%
Line Regulation		ΔV_{LINE}	V_{IN} = 3V to 5.5V, I_{OUT} = 10mA		0.1	0.2	%
EN Threshold Voltage	Logic-Low	V_{IL}		--	--	0.6	V
	Logic-High	V_{IH}		1.2	--	--	
Enable Pin Current		I_{EN}	Enable	--	0.1	1	µA

To be continued

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supply Rejection Rate	f = 100Hz	PSRR	I_{OUT} = 300mA	–	–55	–	dB
	f = 10kHz			–	–40	–	
Start-Up Time		T_{Start_Up}	1nF ≤ C_{BP} ≤ 0.1μF	--	40	100	μs
Thermal Shutdown Temperature		T_{SD}		--	170	--	°C
Thermal Shutdown Hysteresis		ΔT_{SD}		--	30	--	

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. 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. The case position of θ_{JC} is on the exposed pad for the VDFN-6L 2x2 packages.

Note 3. Devices are ESD sensitive. Handling precaution recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

Note 5. Quiescent, or ground current, is the difference between input and output currents. It is defined by $I_Q = I_{IN} - I_{OUT}$ under no load condition (I_{OUT} = 0mA). The total current drawn from the supply is the sum of the load current plus the ground pin current.

Note 6. Standby current is the input current drawn by a regulator when the output voltage is disabled by a shutdown signal (V_{EN} >1.8V).

Note 7. The dropout voltage is defined as V_{IN} -V_{OUT}, which is measured when V_{OUT} is $V_{OUT(NORMAL)}$ - 100mV.

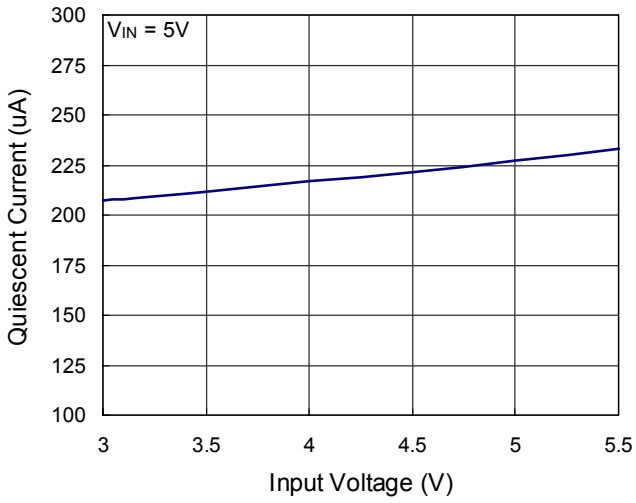
Note 8. Performance at -5°C ≤ T_A ≤ 85°C is assured by design.

Note 9. Regulation is measured at constant junction temperature by using a 2ms current pulse. Devices are tested for load regulation in the load range from 10mA to 500mA.

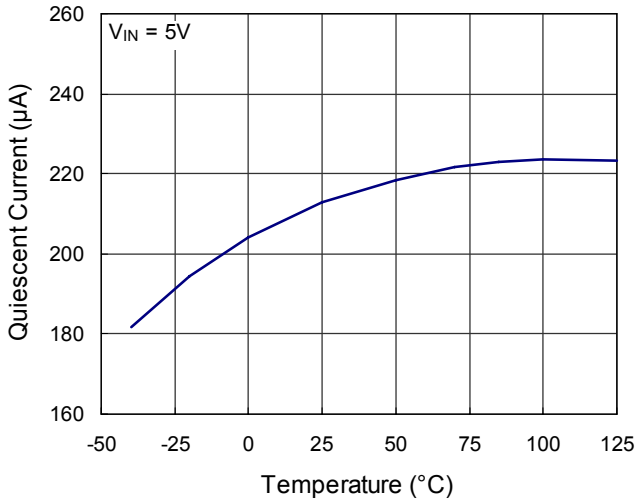
Typical Operating Characteristics

(C_{OUT} = 1µF/X7R, C_{BP} = 10nF, unless otherwise specified)

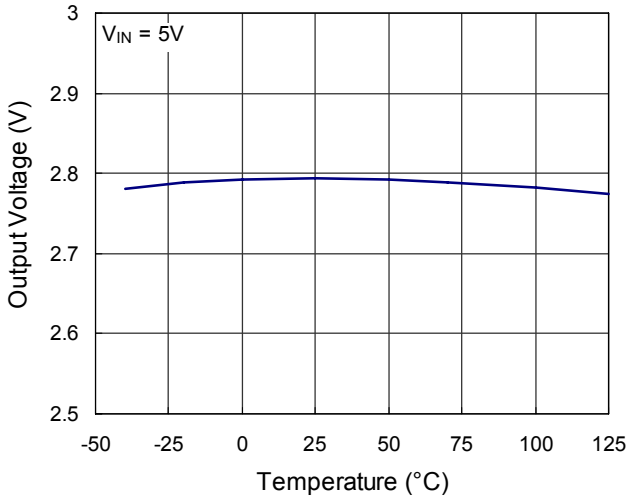
Quiescent Current vs. Input Voltage



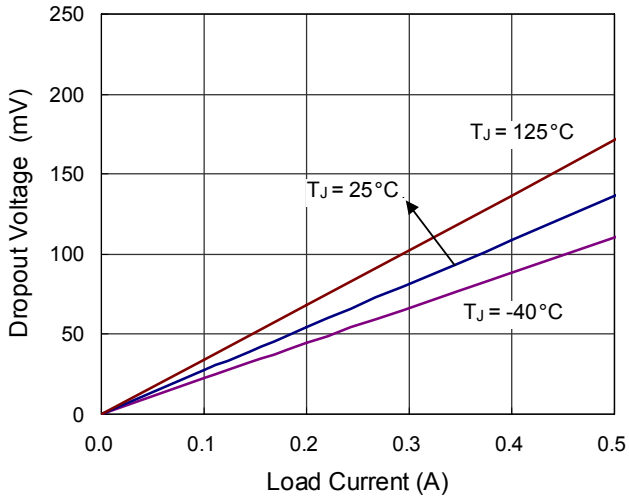
Quiescent Current vs. Temperature



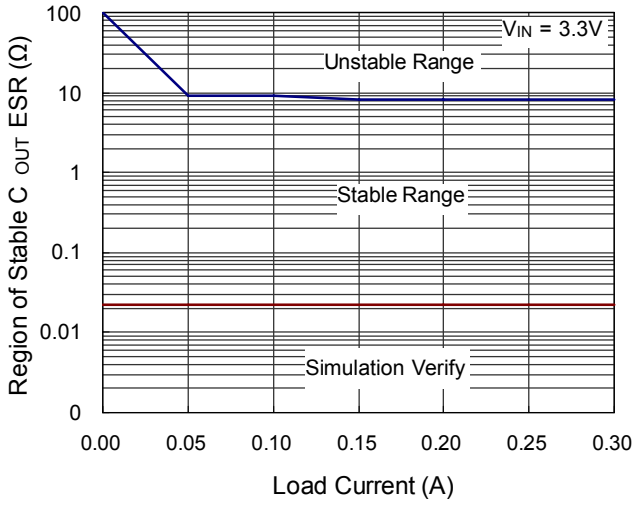
Output Voltage vs. Temperature



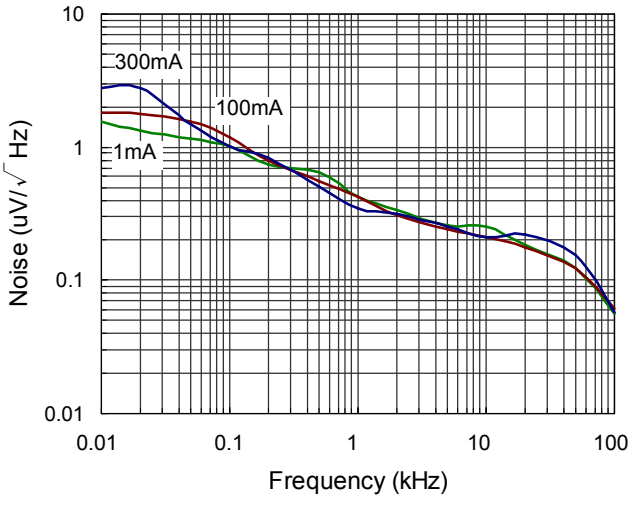
Dropout Voltage vs. Load Current



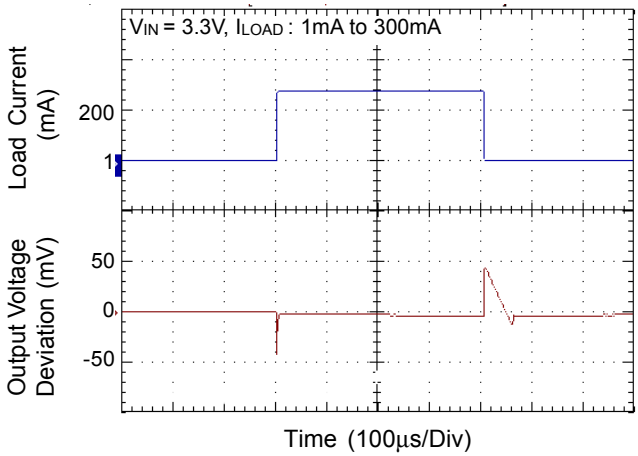
Region of Stable C_{OUT} ESR vs. Load Current



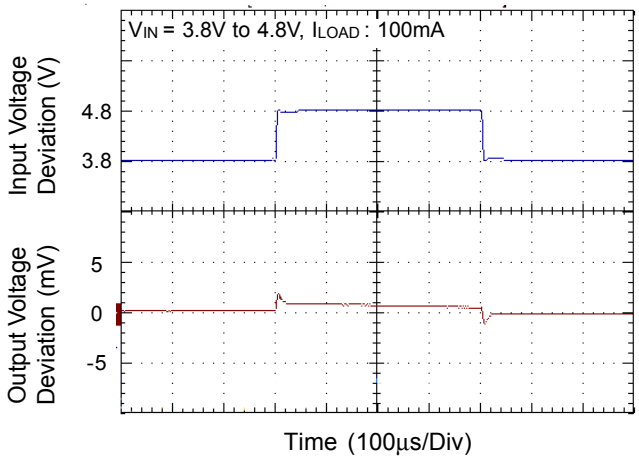
Noise vs. Frequency



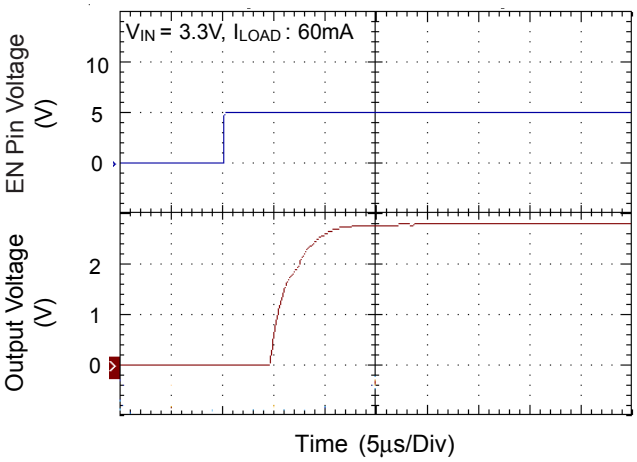
Load Transient Regulation



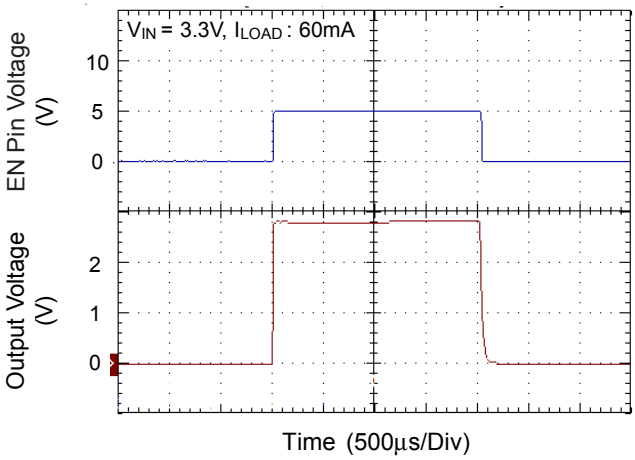
Line Transient Regulation



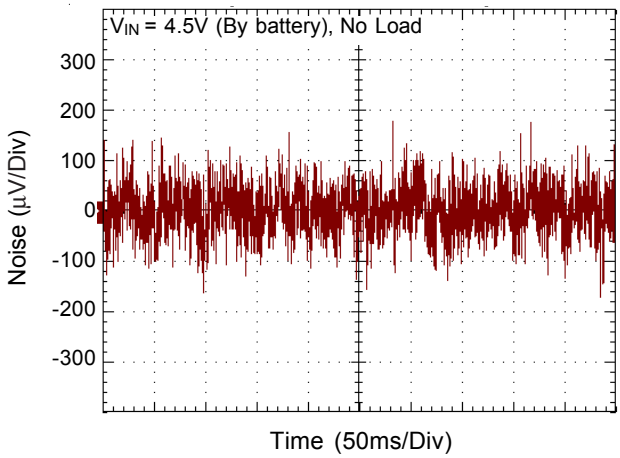
Start Up



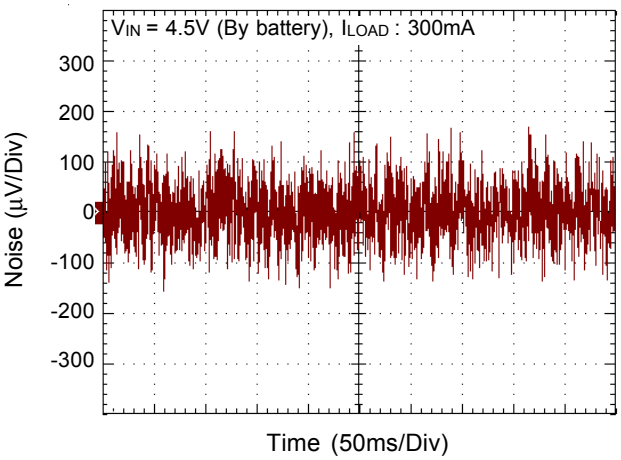
EN Pin Shutdown Response

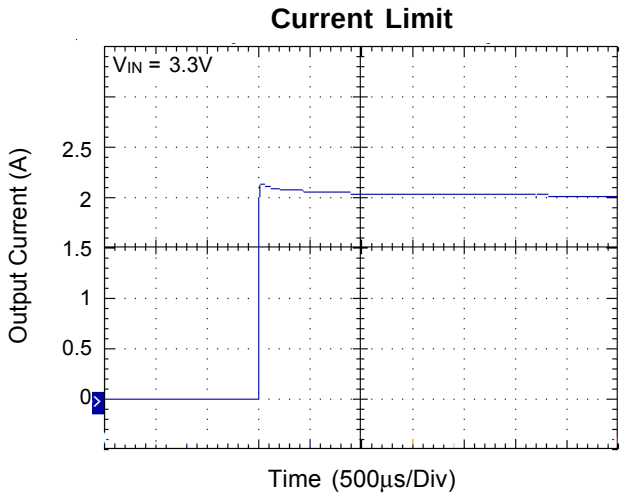


Noise



Noise




Current Limit
VIN = 3.3V
Output Current (A)
2.5
2
1.5
1
0.5
0
Time (500µs/Div)

Applications Information

Enable

The RT9187A goes into sleep mode when the Enable pin is in a logic low condition. During this condition, the pass transistor, error amplifier, and bandgap are turned off, reducing the supply current to 0.1μA typical. The Enable pin may be directly tied to V_{IN} to keep the part on. The Enable input is CMOS logic and cannot be left floating.

Output capacitor

The RT9187A is specifically designed to employ ceramic output capacitors as low as 1μF. Ceramic capacitors below 10μF offer significant cost and space savings, along with high frequency noise filtering. The RT9187A doesn't rely on a zero, which generated by output capacitor ESR. So, output capacitor ESR is not sensitive, very low ESR is allowed

Input capacitor

Good bypassing is recommended from input to ground to help improve AC performance. A 1μF input capacitor or greater located as close as possible to the IC is recommended. Larger input capacitor values with lower ESR provide better supply-noise rejection and line-transient response. Larger load currents may require larger capacitor values. Input capacitor is not critical to stability.

Noise & bypass capacitor

Noise is specified in two ways

Spot Noise or Output noise density is the RMS sum of all noise sources, measured at the regulator output, at a specific frequency (measured with a 1Hz bandwidth). This type of noise is usually plotted on a curve as a function of frequency.

Total output Noise or Broadband noise is the RMS sum of spot noise over a specified bandwidth, usually several decades of frequencies.

Attention should be paid to the units of measurement. Spot noise is measured in units $\mu V/\sqrt{Hz}$ and total output noise is measured in μV(rms).

The internal bandgap reference voltage of the RT9187A can be bypassed with a capacitor to ground to reduce output noise and increase input ripple rejection (PSRR). A quick-start feature allows for quick turn-on of the output voltage. The recommended nominal bypass capacitor is 0.01μF, and an increase won't result in longer turn on times T_{ON}.

PSRR

The power supply rejection ratio (PSRR) is defined as the gain from the input to output divided by the gain from the supply to the output. The PSRR is found to be

$$PSRR = 20 \times \log\left(\frac{\Delta Gain\ Error}{\Delta Supply}\right)$$

Note that when heavy load measuring, Δsupply will cause Δtemperature. And Δtemperature will cause Δoutput voltage. So the heavy load PSRR measuring is include temperature effect.

Current limit

The RT9187A contains an independent current limiter, which monitors and controls the pass transistor's gate voltage, limiting the output current to 2.5A (Typ.). The output can be shorted to ground indefinitely without damaging the part.

Quick start up

The RT9187A provides fast start-up time for better system efficiency. Here uses a voltage source to charges the optional noise bypass capacitor. Unlike traditional current source, the start-up times won't increase with bypass capacitor.

Thermal Shutdown protection

Thermal shutdown protection limits total power dissipation in the RT9187A. When the junction temperature exceeds T_J = +170°C, the thermal sensor signals the shutdown logic, turning off the pass transistor and allowing the IC to cool. The thermal sensor turns the pass transistor on again after the IC's junction temperature cools by 30°C, resulting in a pulsed output during continuous thermal overload conditions. Thermal-shutdown protection is designed to protect the RT9187A in the event of fault conditions. For continual operation, do not exceed the absolute maximum junction temperature rating of T_J = +125°C.

Power Dissipation

For continuous operation, do not exceed absolute maximum operation junction temperature 125°C. The power dissipation definition in device is :

$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_Q$

The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junctions 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 RT9187A, 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 package is 220°C/W and VDFN-6L 2x2 package is 165°C/W on 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) / 220 = 0.454W for SOT-23-5 package

$P_{D(MAX)}$ = (125°C – 25°C) / 165 = 0.606W for VDFN-6L 2x2 package

The maximum power dissipation depends on operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance θ_{JA}. For RT9187A packages, the Figure 1 of derating curves allows the designer to see the effect of rising ambient temperature on the maximum power allowed.

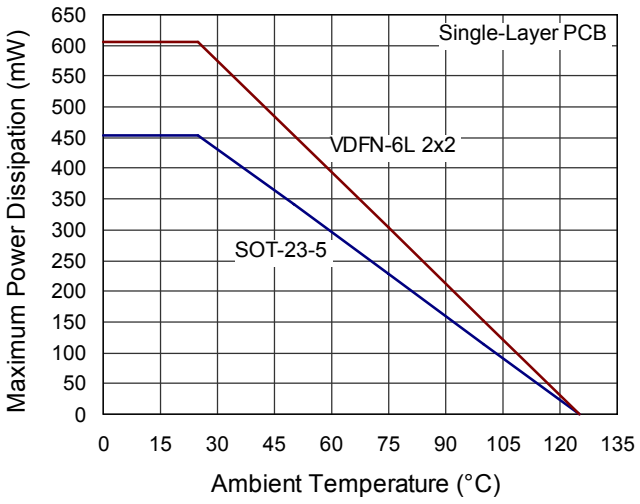
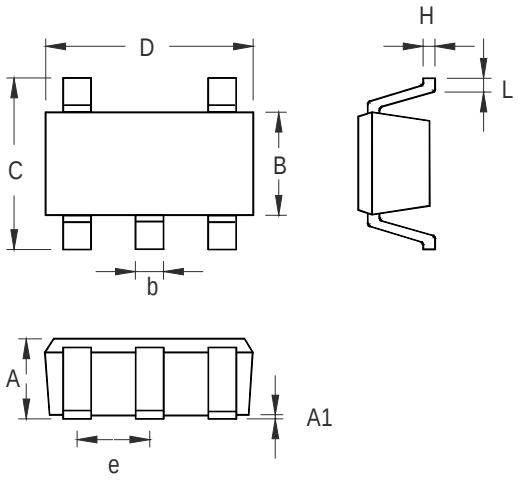


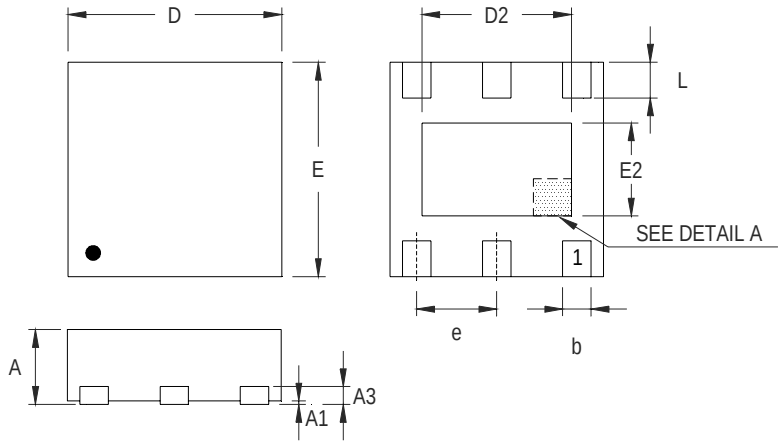
Figure 1. Derating Curves for RT9187A Package

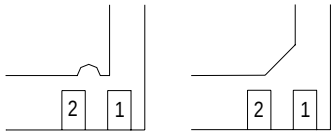
Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.356	0.559	0.014	0.022
C	2.591	2.997	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

SOT-23-5 Surface Mount Package





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.000	0.031	0.039
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.200	0.350	0.008	0.014
D	1.950	2.050	0.077	0.081
D2	1.000	1.450	0.039	0.057
E	1.950	2.050	0.077	0.081
E2	0.500	0.850	0.020	0.033
e	0.650		0.026	
L	0.300	0.400	0.012	0.016

V-Type 6L DFN 2x2 Package

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