

# 300mA, Thermal Folded Back CMOS LDO Regulator

## General Description

The RT9198T is designed for portable RF and wireless applications with demanding performance and space requirements. The RT9198T performance is optimized for battery-powered systems to deliver ultra low noise and low quiescent current. Regulator ground current increases only slightly in dropout, further prolonging the battery life. The RT9198T also works with low-ESR ceramic capacitors, reducing the amount of board space necessary for power applications, critical in hand-held wireless devices. The RT9198T consumes less than 0.01uA in shutdown mode and has fast turn-on time less than 50µs. RT9198T is short circuit thermal folded back protected. RT9198T lowers its OTP trip point from 165°C to 110°C when output short circuit occurs ( $V_{OUT} < 0.4V$ ) providing maximum safety to end users. The other features include ultra low dropout voltage, high output accuracy, current limiting protection, and high ripple rejection ratio. Available in the SOT-23-3, SOT-23-5 and SC-70-5 packages, the RT9198T also offers a range of 1.5V to 3.5V with 0.1V per step.

## Ordering Information

RT9198T-□□□□	
	Package Type
	U5 : SC-70-5
	U5R : SC-70-5 (R-Type)
	V : SOT-23-3
	B : SOT- 23-5
	BR : SOT- 23-5 (R-Type)
	Lead Plating System
	P : Pb Free
	G : Green (Halogen Free and Pb Free)
	Output Voltage
	15 : 1.5V
	16 : 1.6V
	:
	34 : 3.4V
	35 : 3.5V
	1H : 1.85V
	2H : 2.85V

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.

## Features

- Short Circuit Thermal Folded Back Protection
- Low-Noise for RF Application
- Fast Response in Line/Load Transient
- Quick Start-Up (Typically 50us)
- < 0.01uA Standby Current When Shutdown
- Low Dropout : 220mV @ 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 1uF Output Capacitor Required for Stability
- High Power Supply Rejection Ratio
- Custom Voltage Available
- RoHS Compliant and 100% Lead (Pb)-Free

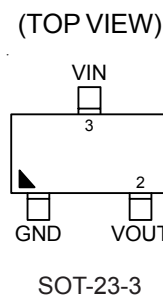
## Applications

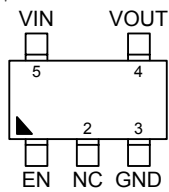
- CDMA/GSM Cellular Handsets
- Battery-Powered Equipment
- Laptop, Palmtops, Notebook Computers
- Hand-Held Instruments
- PCMCIA Cards
- Portable Information Appliances

## Marking Information

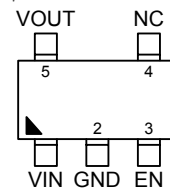
For marking information, contact our sales representative directly or through a Richtek distributor located in your area.

## Pin Configurations



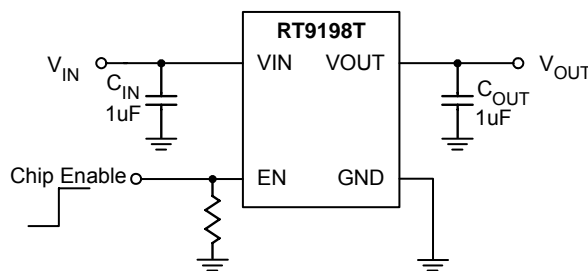


SOT-23-5/SC-70-5



SOT-23-5/SC-70-5 (R-Type)

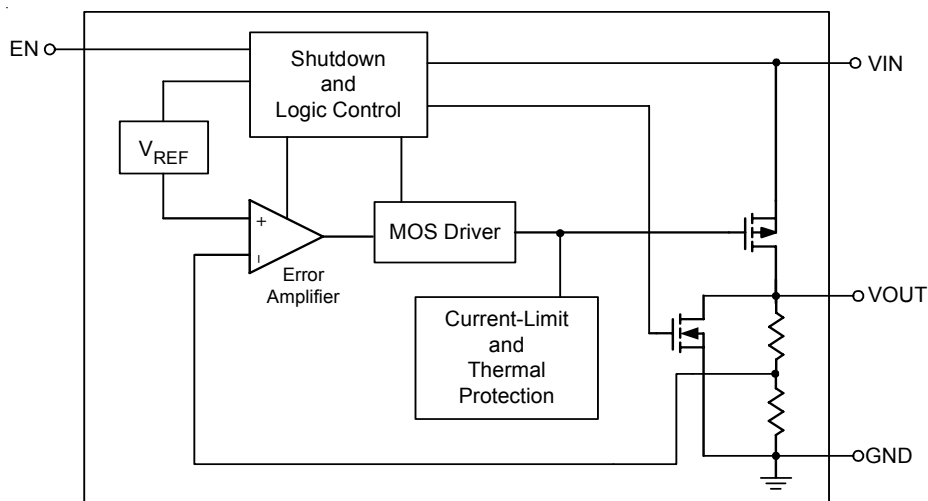
## Typical Application Circuit



## Functional Pin Description

Pin Name	Pin Function
EN	Chip Enable (Active High). Note that this pin is high impedance. There should be a pull low 100kΩ resistor connected to GND when the control signal is floating.
NC	No Connection
GND	Ground
VOUT	Output Voltage
VIN	Input Voltage

## Function Block Diagram



**Absolute Maximum Ratings** (Note 1)

- Supply Input Voltage ----- 6V
- Power Dissipation,  $P_D$  @  $T_A = 25^\circ\text{C}$ 
  - SOT-23-3 ----- 0.4W
  - SOT-23-5 ----- 0.4W
  - SC-70-5 ----- 0.3W
- Package Thermal Resistance (Note 2)
  - SOT-23-3,  $\theta_{JA}$  -----  $250^\circ\text{C/W}$
  - SOT-23-5,  $\theta_{JA}$  -----  $250^\circ\text{C/W}$
  - SC-70-5,  $\theta_{JA}$  -----  $333^\circ\text{C/W}$
- Junction Temperature -----  $150^\circ\text{C}$
- Lead Temperature (Soldering, 10 sec.) -----  $260^\circ\text{C}$
- Storage Temperature Range -----  $-65^\circ\text{C}$  to  $150^\circ\text{C}$
- ESD Susceptibility (Note 3)
  - HBM (Human Body Mode) ----- 2kV
  - MM (Machine Mode) ----- 200V

**Recommended Operating Conditions** (Note 4)

- Supply Input Voltage ----- 2.5V to 5.5V
- Operation Ambient Temperature Range -----  $-40^\circ\text{C}$  to  $85^\circ\text{C}$
- Operation Junction Temperature Range -----  $-40^\circ\text{C}$  to  $125^\circ\text{C}$

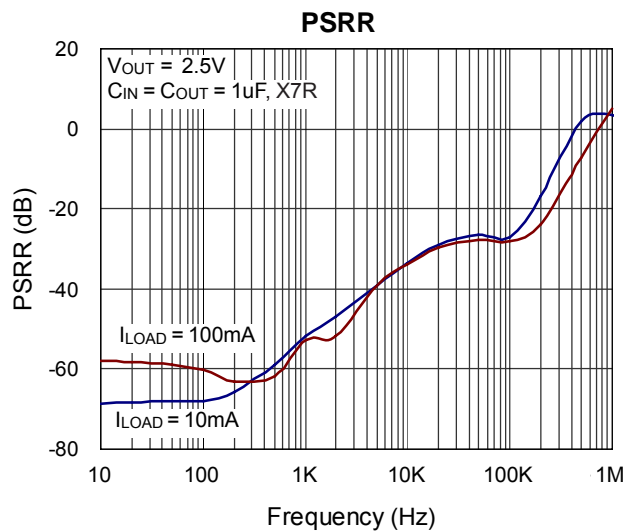
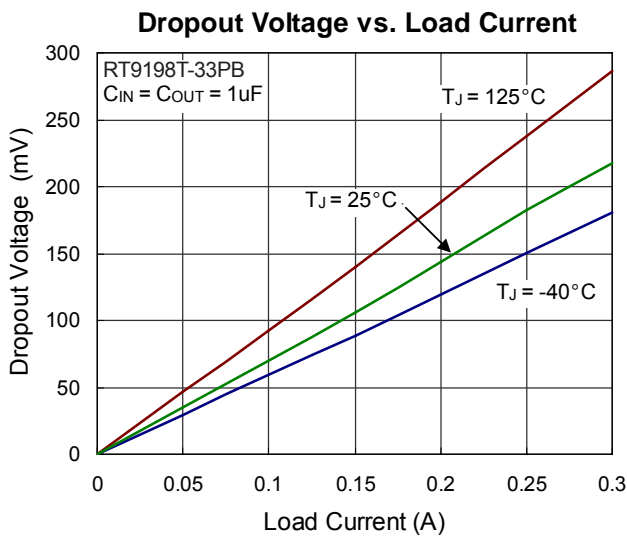
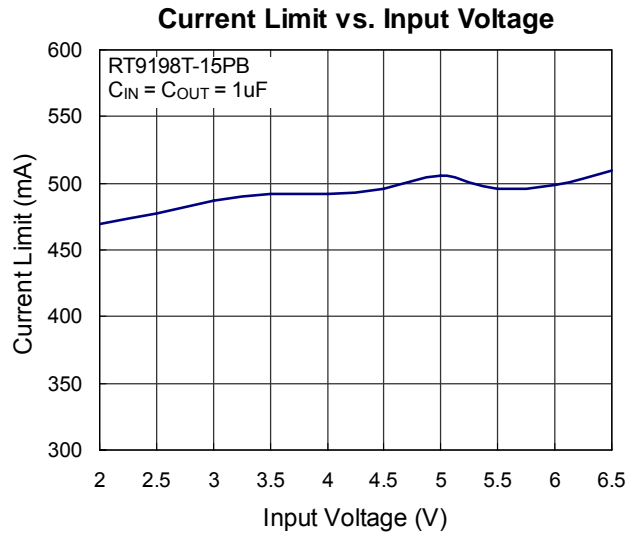
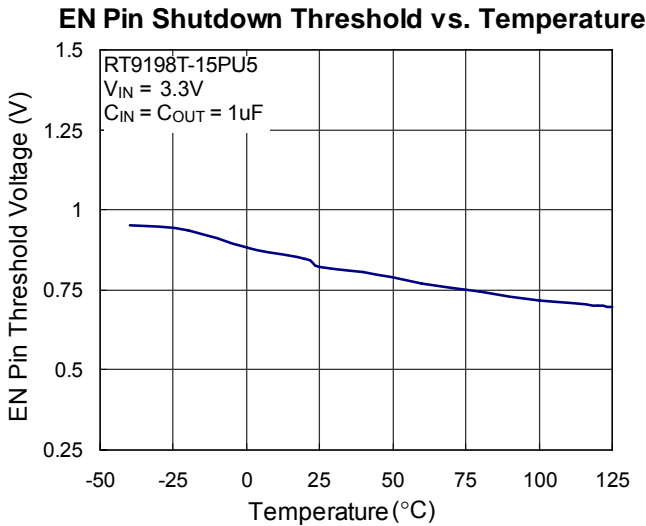
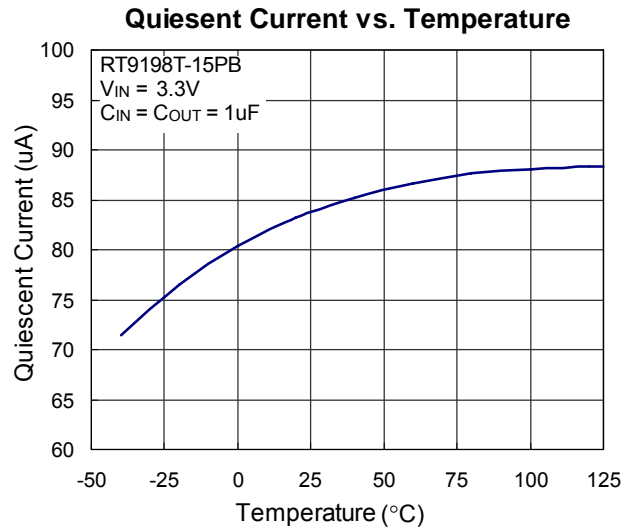
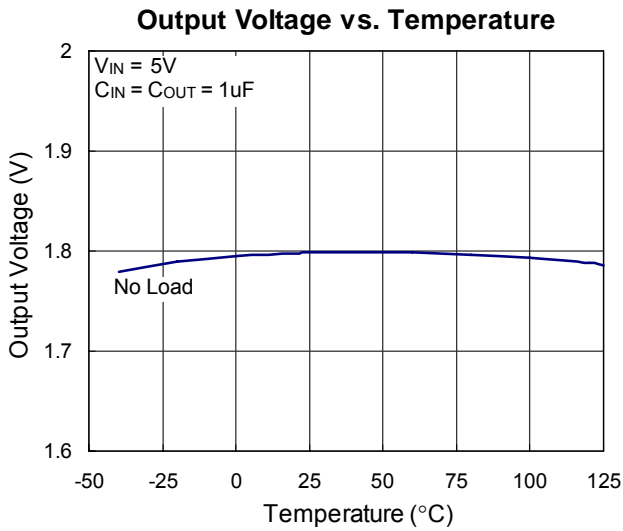
**Electrical Characteristics**

( $V_{IN} = V_{OUT} + 1V$ ,  $C_{IN} = C_{OUT} = 1\mu\text{F}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified)

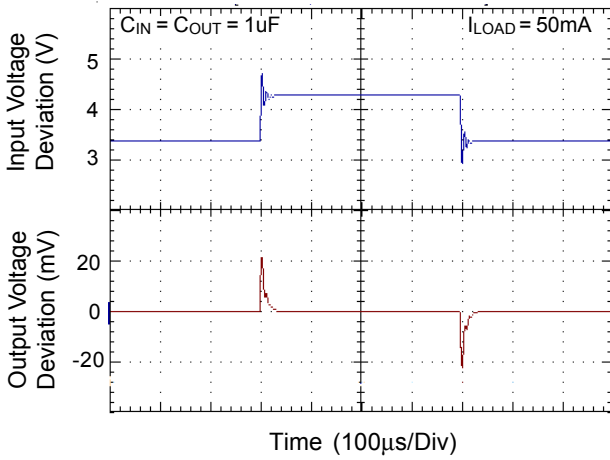
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit	
Output Voltage Accuracy	$\Delta V_{OUT}$	$I_{OUT} = 1\text{mA}$	-2	--	+2	%	
Current Limit	$I_{LIM}$	$R_{LOAD} = 1\Omega$	360	400	--	mA	
Quiescent Current	$I_Q$	$V_{EN} \geq 1.2V$ , $I_{OUT} = 0\text{mA}$	--	90	130	$\mu\text{A}$	
Dropout Voltage (Note 5)	$V_{DROP}$	$I_{OUT} = 200\text{mA}$	--	170	200	mV	
		$I_{OUT} = 300\text{mA}$	--	220	330		
Line Regulation	$\Delta V_{LINE}$	$V_{IN} = (V_{OUT} + 1V)$ to $5.5V$ , $I_{OUT} = 1\text{mA}$	--	--	0.3	%	
Load Regulation	$\Delta V_{LOAD}$	$1\text{mA} < I_{OUT} < 300\text{mA}$	--	--	0.6	%	
Standby Current	$I_{STBY}$	$V_{EN} = \text{GND}$ , Shutdown	--	0.01	1	$\mu\text{A}$	
EN Input Bias Current	$I_{IBSD}$	$V_{EN} = \text{GND}$ or $V_{IN}$	--	0	100	nA	
EN Threshold	Logic-Low Voltage	$V_{IL}$	$V_{IN} = 3V$ to $5.5V$ , Shutdown	--	--	0.4	V
	Logic-High Voltage	$V_{IH}$	$V_{IN} = 3V$ to $5.5V$ , Start-Up	1.2	--	--	
Power Supply Rejection Rate	$f = 100\text{Hz}$	PSRR	$C_{OUT} = 1\mu\text{F}$ , $I_{OUT} = 100\text{mA}$	--	-60	--	dB
	$f = 10\text{kHz}$			--	-30	--	
Thermal Shutdown Temperature	$T_{SD}$		--	165	--	$^\circ\text{C}$	
Thermal Shutdown Temperature Hysteresis	$\Delta T_{SD}$		--	30	--	$^\circ\text{C}$	
Thermal Folded Back			--	110	--	$^\circ\text{C}$	

- 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.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ\text{C}$  on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.
- Note 3.** Devices are ESD sensitive. Handling precaution is recommended.
- Note 4.** The device is not guaranteed to function outside its operating conditions.
- Note 5.** The dropout voltage is defined as  $V_{IN} - V_{OUT}$ , which is measured when  $V_{OUT}$  is  $V_{OUT(NORMAL)} - 100\text{mV}$ .

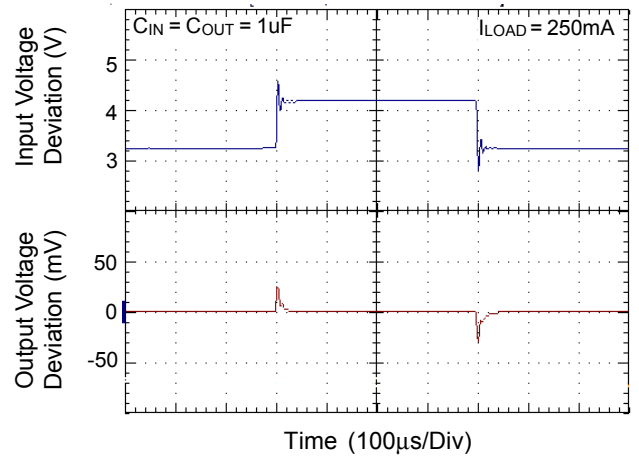
**Typical Operating Characteristics**



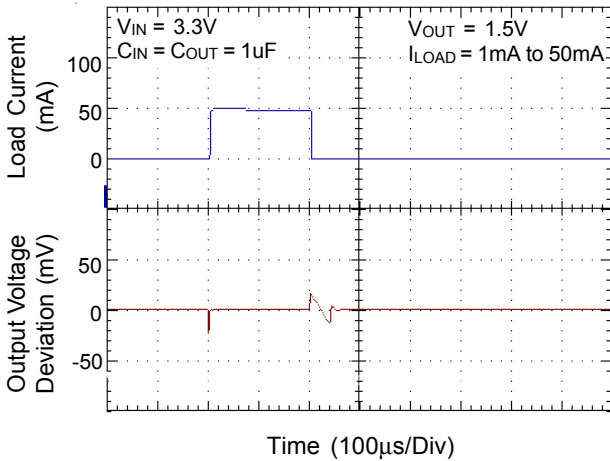
Line Transient Response



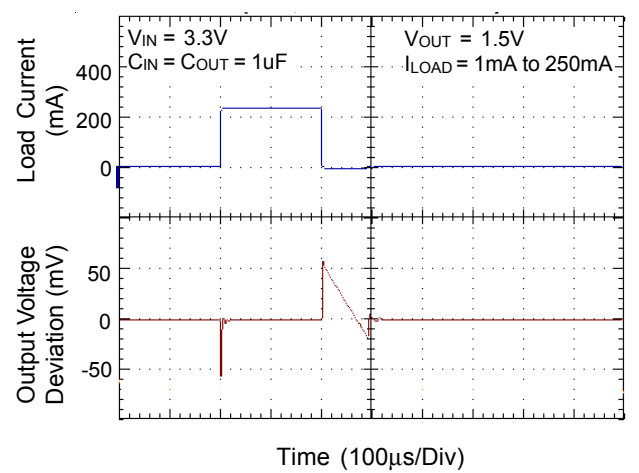
Line Transient Response



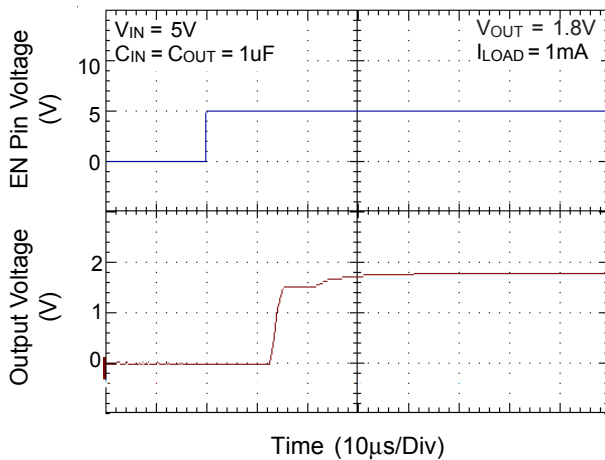
Load Transient Response



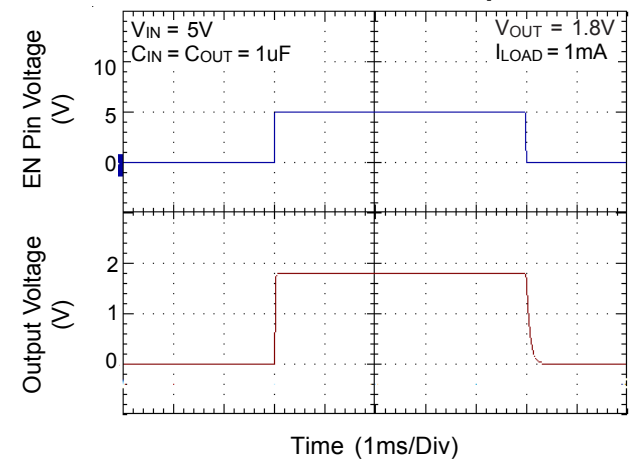
Load Transient Response

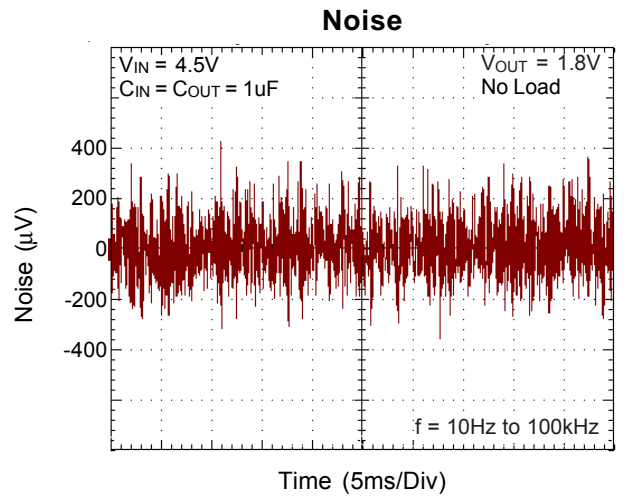
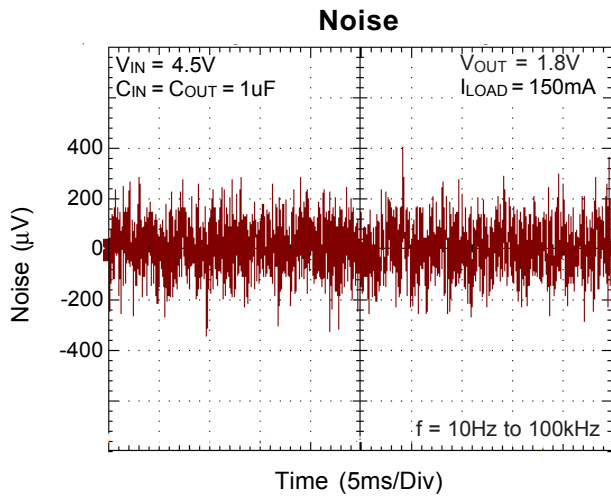


Start Up



EN Pin Shutdown Response





## Applications Information

Like any low-dropout regulator, the external capacitors used with the RT9198T must be carefully selected for regulator stability and performance. Using a capacitor whose value is  $> 1\mu\text{F}$  on the RT9198T input and the amount of capacitance can be increased without limit. The input capacitor must be located a distance of not more than 0.5 inch from the input pin of the IC and returned to a clean analog ground. Any good quality ceramic or tantalum can be used for this capacitor. The capacitor with larger value and lower ESR (equivalent series resistance) provides better PSRR and line-transient response.

The output capacitor must meet both requirements for minimum amount of capacitance and ESR in all LDOs application. The RT9198T is designed specifically to work with low ESR ceramic output capacitor in space-saving and performance consideration. Using a ceramic capacitor whose value is at least  $1\mu\text{F}$  with ESR is  $> 20\text{m}\Omega$  on the RT9198T output ensures stability. The RT9198T still works well with output capacitor of other types due to the wide stable ESR range. Figure 1. shows the curves of allowable ESR range as a function of load current for various output capacitor values. Output capacitor of larger capacitance can reduce noise and improve load transient response, stability, and PSRR. The output capacitor should be located not more than 0.5 inch from the  $V_{\text{OUT}}$  pin of the RT9198T and returned to a clean analog ground.

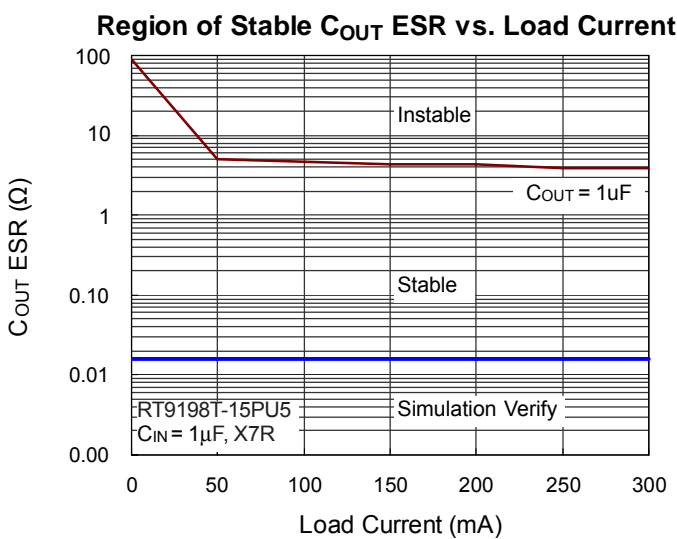


Figure 1

## Enable Function

The RT9198T features an LDO regulator enable/disable function. To assure the LDO regulator will switch on, the EN turn on control level must be greater than 1.2 volts. The LDO regulator will go into the shutdown mode when the voltage on the EN pin falls below 0.4 volts. For protecting the system, the RT9198T have a quick-discharge function. If the enable function is not needed in a specific application, it may be tied to  $V_{\text{IN}}$  to keep the LDO regulator in a continuously on state.

## Thermal Considerations

Thermal protection limits power dissipation in RT9198T. When the operation junction temperature exceeds  $165^\circ\text{C}$ , the OTP circuit starts the thermal shutdown function and turns the pass element off. The pass element turn on again after the junction temperature cools by  $30^\circ\text{C}$ .

RT9198T lowers its OTP trip level from  $165^\circ\text{C}$  to  $110^\circ\text{C}$  when output short circuit occurs ( $V_{\text{OUT}} < 0.4\text{V}$ ) as shown in Figure 2. This limits IC case temperature under  $100^\circ\text{C}$  and provides maximum safety to end users when output short circuit occurs.

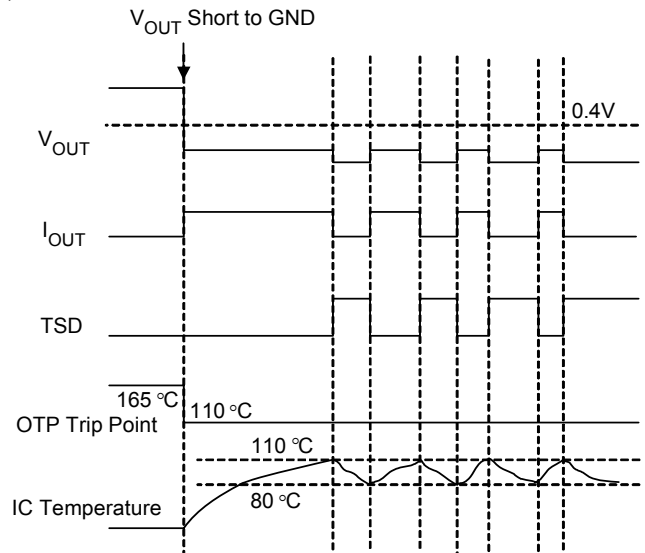


Figure 2. Short Circuit Thermal Folded Back Protection when Output Short Circuit Occurs



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 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  $\theta_{JA}$  is the junction to ambient thermal resistance.

For recommended operating conditions specification of RT9198T, 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 ( $\theta_{JA}$  is layout dependent) for SC-70 package is 333°C/W, 250°C/W is for SOT-23-3 and SOT-23-5 package on standard JEDEC 51-3 thermal test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated by following formula :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / 250 = 400 \text{ mW (SOT-23-3/ SOT-23-5)}$$

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / 333 = 300 \text{ mW (SC-70-5)}$$

The maximum power dissipation depends on operating ambient temperature for fixed  $T_{J(MAX)}$  and thermal resistance  $\theta_{JA}$ . For RT9198T packages, the Figure 3. of derating curves allows the designer to see the effect of rising ambient temperature on the maximum power allowed.

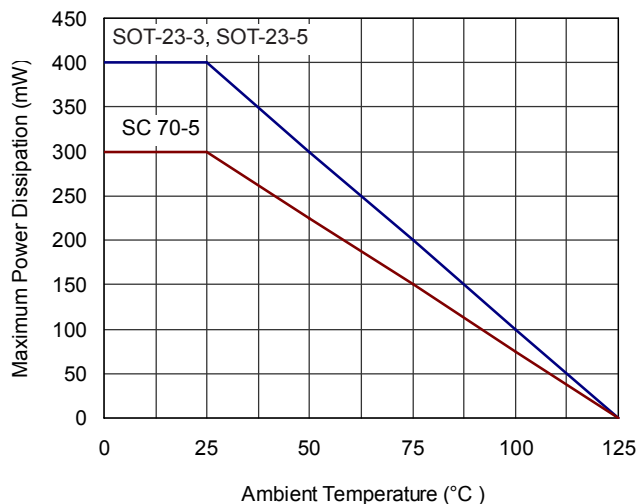
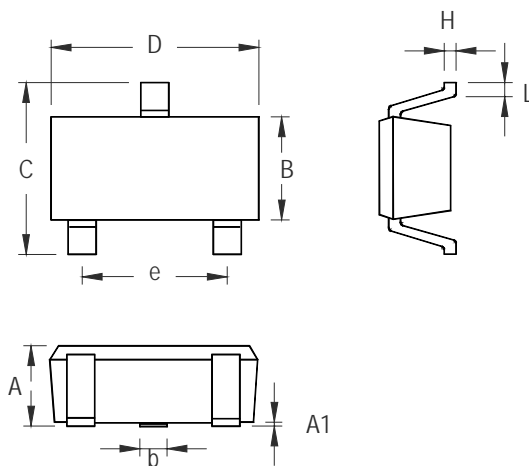


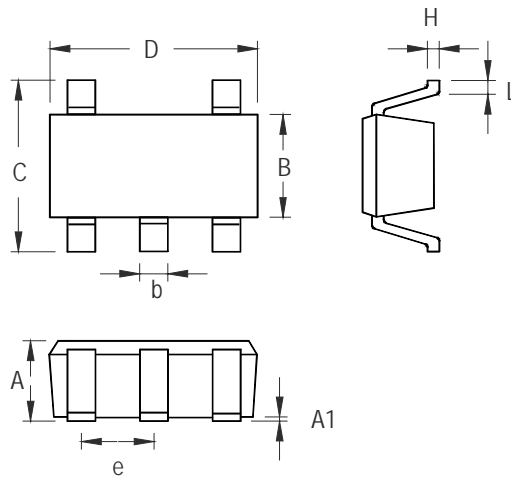
Figure 3. Derating Curve for Packages

## Outline Dimension



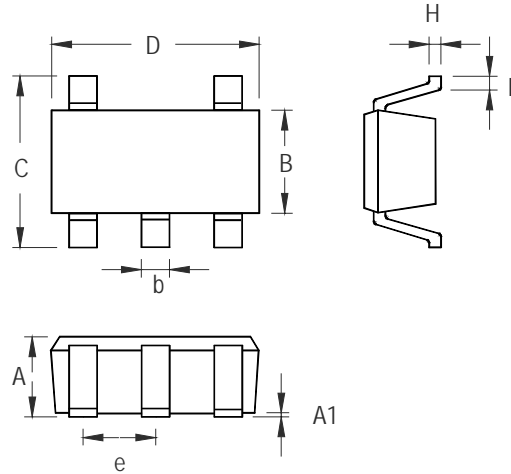
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.356	0.508	0.014	0.020
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	1.803	2.007	0.071	0.079
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

**SOT-23-3 Surface Mount Package**



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**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.100	0.031	0.044
A1	0.000	0.100	0.000	0.004
B	1.150	1.350	0.045	0.054
b	0.150	0.400	0.006	0.016
C	1.800	2.450	0.071	0.096
D	1.800	2.250	0.071	0.089
e	0.650		0.026	
H	0.080	0.260	0.003	0.010
L	0.210	0.460	0.008	0.018

**SC-70-5 Surface Mount Package**

**Richtek Technology Corporation**

Headquarter  
 5F, No. 20, Taiyuen Street, Chupei City  
 Hsinchu, Taiwan, R.O.C.  
 Tel: (8863)5526789 Fax: (8863)5526611

**Richtek Technology Corporation**

Taipei Office (Marketing)  
 5F, No. 95, Minchiuan Road, Hsintien City  
 Taipei County, Taiwan, R.O.C.  
 Tel: (8862)86672399 Fax: (8862)86672377  
 Email: marketing@richtek.com

Information that is provided by Richtek Technology Corporation is believed to be accurate and reliable. Richtek reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. No third party intellectual property infringement of the applications should be guaranteed by users when integrating Richtek products into any application. No legal responsibility for any said applications is assumed by Richtek.