

## 300mA Ultra-low Noise, Ultra-Fast CMOS LDO Regulator

# LR9198

### FEATURES

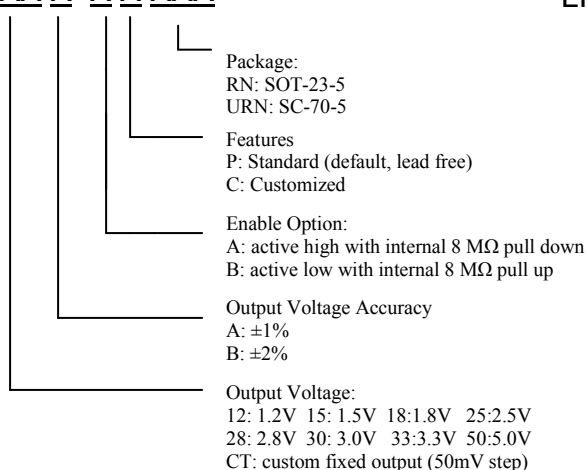
- Ultra-low Noise for RF Application
- Ultra-Fast Response in Line/Load Transient
- $<0.01\mu\text{A}$  Standby Current When Shutdown.
- Low Dropout:  $210\text{mV}@300\text{mA}$
- Wide Operating Voltage Ranges:  $2\text{V}$  to  $6\text{V}$
- TTL-logic-Controlled Shutdown Input
- Low Temperature Coefficient
- Current Limiting Protection
- Thermal Shutdown Protection
- Only  $1\mu\text{F}$  Output Capacitor Required for Stability
- High Power Supply Rejection Ratio
- Custom Voltage Available
- Fast output discharge
- Available in 5-Lead SOT-23 and SC-70 Package

### APPLICATIONS

- Cellular and Smart Phones
- Battery-Powered Equipment
- Laptop, Palmtops, Notebook Computers

### ORDERING INFORMATION

LR9198 XX X X XXX



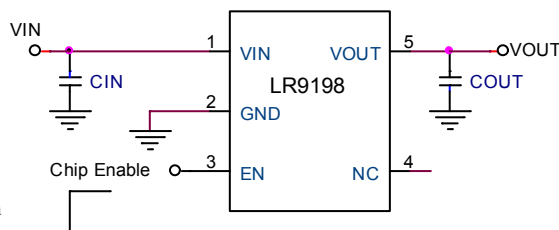
- Hand-Held Instruments
- PCMCIA Cards
- MP3/MP4/MP5 Players
- Portable Information Appliances

### DESCRIPTION

The LR9198 is designed for portable RF and wireless applications with demanding performance and space requirements. The LR9198 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 LR9198 also works with low-ESR ceramic capacitors, reducing the amount of board space necessary for power applications, critical in hand-held wireless devices. The LR9198 consumes less than  $0.01\mu\text{A}$  in shutdown mode and has fast turn-on time less than  $50\mu\text{s}$ . The other features include ultra low dropout voltage, high output accuracy, current limiting protection, and high ripple rejection ratio. Available in the 5-lead SC-70 and SOT-23 packages.

### TYPICAL APPLICATION

LR9198 28 AA



#### Application hints:

Output capacitor ( $\text{COUT} \geq 2.2\mu\text{F}$ ) is recommended in LR9198- $1.2\text{V}$  application to assure the stability of circuit.

## Absolute Maximum Rating <sup>(Note 1)</sup>

Input Supply Voltage ( $V_{IN}$ )	-0.3V to +6V
EN Input Voltage	-0.3V to + $V_{IN}$
Output Voltage	-0.3V to $V_{IN}+0.3V$
Output Current	300mA

Maximum Junction Temperature	125°C
Operating Temperature Range <sup>(Note2)</sup>	-40°C to 85°C
Storage Temperature Range	-65°C to 125°C
Lead Temperature (Soldering, 10s)	300°C

## Package Information

SOT23-5/SC70-5 TOP VIEW		
VIN	1	5 VOUT
GND	2	
EN	3	4 NC
MARKING		
Part Number	Top Mark	Temp Range
LR9198-12	E A Y W <sup>(Note3)</sup>	-40°C to +85°C
LR9198-15	E B Y W	-40°C to +85°C
LR9198-18	E C Y W	-40°C to +85°C
LR9198-25	E D Y W	-40°C to +85°C
LR9198-28	E E Y W	-40°C to +85°C
LR9198-30	E F Y W	-40°C to +85°C
LR9198-33	E G Y W	-40°C to +85°C
LR9198-50	E I Y W	-40°C to +85°C

## Thermal Resistance <sup>(Note 4)</sup>

Package	$\Theta_{JA}$	$\Theta_{JC}$
SOT23-5	250°C/W	130°C/W
SC70-5	333°C/W	170°C/W

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** The LR9198 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

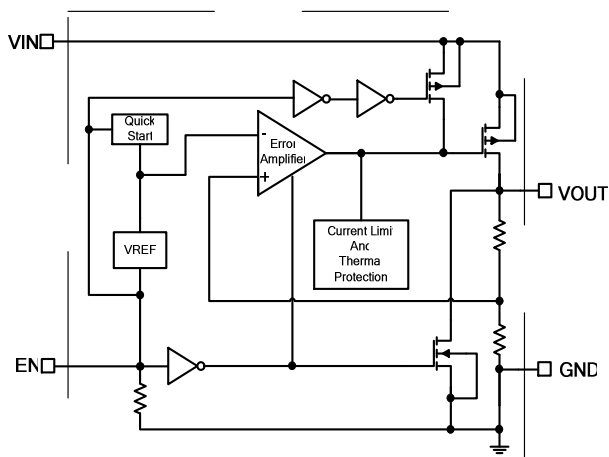
**Note 3:** X: Product Code(LR9198:E) V: Voltage Code(1.2V:A, 1.5V:B, 1.8V:C, 2.5V:D, 2.8V:E, 3.0V:F, 3.3V:G, 5.0V:I) Y: Year of manufacturing(9:2009) W: Week of manufacturing(W:A-Z, a-z).

**Note 4:** Thermal Resistance is specified with approximately 1 square of 1 oz copper.

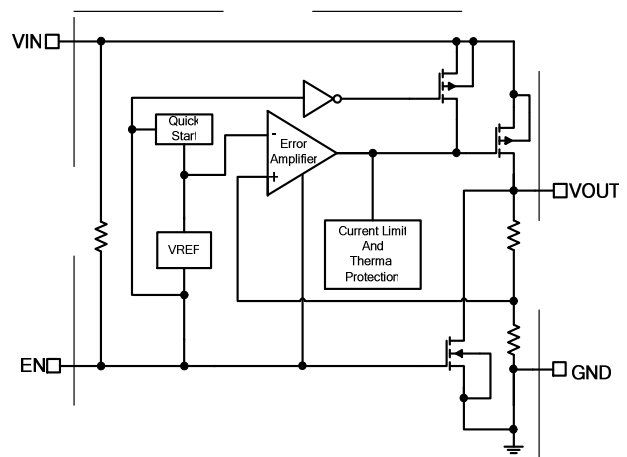
## Pin Description

PIN	NAME	FUNCTION
1	VIN	Power Input Voltage.
2	GND	Ground.
3	EN	Chip Enable Pin with two options. A: active high with internal 8 MΩ pull down B: active low with internal 8 MΩ pull up
4	NC	No Connection.
5	VOUT	Output Voltage.

## Block Diagram



LR9198 XX XA



LR9198 XX XB

## Electrical Characteristics (Note 5)

( $V_{IN}=3.6V$ ,  $EN=V_{IN}$ ,  $C_{IN}=C_{OUT}=1\mu F$ ,  $T_A=25^\circ C$ , unless otherwise noted.)

Parameter		Symbol	Conditions	MIN	TYP	MAX	unit
Input Voltage		$V_{IN}$		2		6	V
Output Voltage Accuracy (Note 6)		$\Delta V_{OUT}$	$V_{IN}=3.6V$ , $I_{OUT}=1mA$	-1		+1	%
				-2		+2	
Current Limit		$I_{LIM}$	$R_{LOAD}=1\Omega$	400	430		mA
Quiescent Current		$I_Q$	$V_{EN}>1.2V$ , $I_{OUT}=0mA$		90	130	$\mu A$
Dropout Voltage		$V_{DROP}$	$I_{OUT}=200mA$ , $V_{OUT}=2.8V$		130	180	mV
			$I_{OUT}=300mA$ , $V_{OUT}=2.8V$		210	300	
Line Regulation (Note 7)		$\Delta V_{LINE}$	$V_{IN}=3.6V$ to $5.5V$ $I_{OUT}=1mA$		0.05	0.17	%/V
Load Regulation (Note 8)		$\Delta V_{LOAD}$	$1mA < I_{OUT} < 300mA$			2	%/A
Output Voltage Temperature Coefficient (Note 9)		$TC_{VOUT}$	$I_{OUT}=1mA$		$\pm 60$		ppm/ $^\circ C$
Standby Current		$I_{STBY}$	$V_{EN}=GND$ , Shutdown		0.01	1	$\mu A$
EN Input Bias Current		$I_{IBSD}$	$V_{EN}=GND$ or $V_{IN}$			500	nA
EN Input Threshold	Logic Low	$V_{IL}$	$V_{IN}=3V$ to $5.5V$ , Shutdown			0.4	V
	Logic High	$V_{IH}$	$V_{IN}=3V$ to $5.5V$ , Start up	1.2			V
Output Noise Voltage		$e_{NO}$	10Hz to 100KHz, $I_{OUT}=200mA$		100		$\mu V_{RMS}$
Power Supply Rejection Ratio	f=217Hz	PSRR	$I_{OUT}=100mA$		-78		dB
	f=1KHz				-72		
	f=10KHz				-52		
Thermal Shutdown Temperature		$T_{SD}$	Shutdown, Temp increasing		165		$^\circ C$
Thermal Shutdown Hysteresis		$T_{SDHY}$			30		$^\circ C$

**Note 5:** 100% production test at  $+25^\circ C$ . Specifications over the temperature range are guaranteed by design and characterization.

**Note 6:** This IC includes two kinds of output voltage accuracy versions. A:  $\pm 1\%$ , B:  $\pm 2\%$ .

**Note 7:** Line regulation is calculated by  $\Delta V_{LINE} = \left( \frac{V_{OUT1} - V_{OUT2}}{\Delta V_{IN} \times V_{OUT(normal)}} \right) \times 100$

Where  $V_{OUT1}$  is the output voltage when  $V_{IN}=5.5V$ , and  $V_{OUT2}$  is the output voltage when  $V_{IN}=3.6V$ ,  $\Delta V_{IN}=1.9V$ .  $V_{OUT(normal)}=2.8V$ .

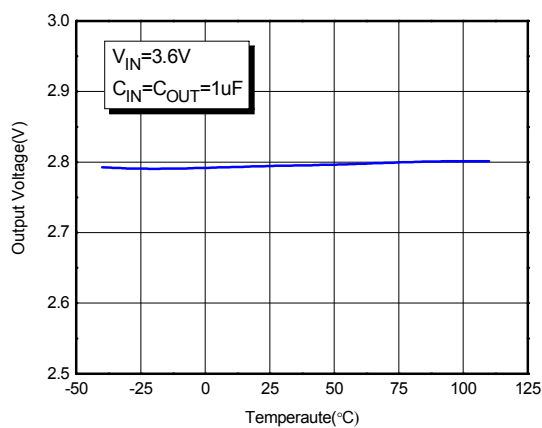
**Note 8:** Load regulation is calculated by  $\Delta V_{LOAD} = \left( \frac{V_{OUT1} - V_{OUT2}}{\Delta I_{OUT} \times V_{OUT(normal)}} \right) \times 100$

Where  $V_{OUT1}$  is the output voltage when  $I_{OUT}=1mA$ , and  $V_{OUT2}$  is the output voltage when  $I_{OUT}=300mA$ .  $\Delta I_{OUT}=0.299A$ ,  $V_{OUT(normal)}=2.8V$ .

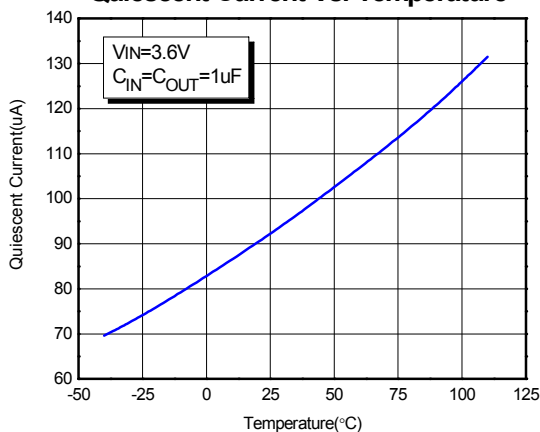
**Note 9:** The temperature coefficient is calculated by  $TC_{VOUT} = \frac{\Delta V_{OUT}}{\Delta T \times V_{OUT}}$

## Typical Performance Characteristics

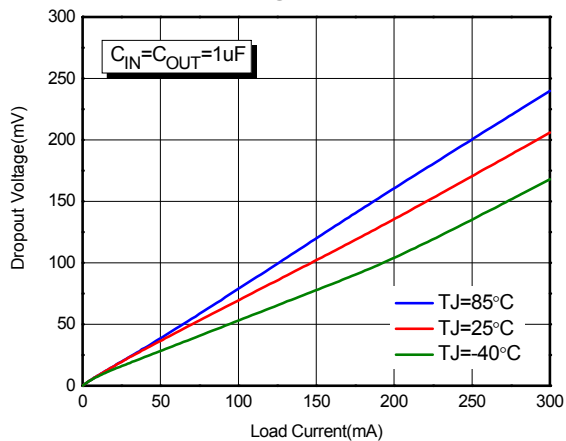
Output Voltage Vs. Temperature



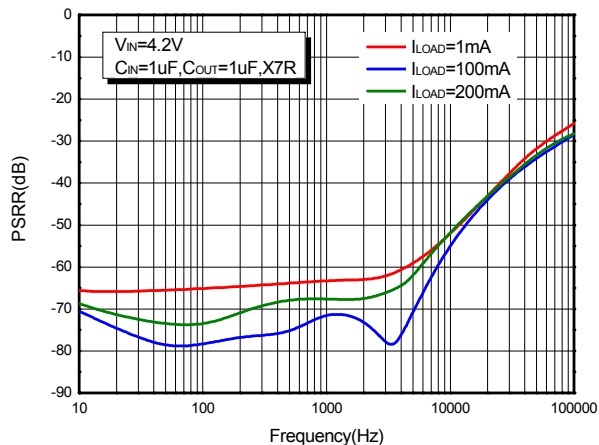
Quiescent Current Vs. Temperature



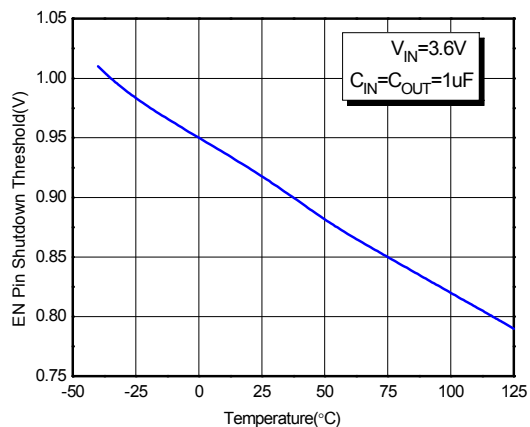
Dropout Voltage Vs. Load Current



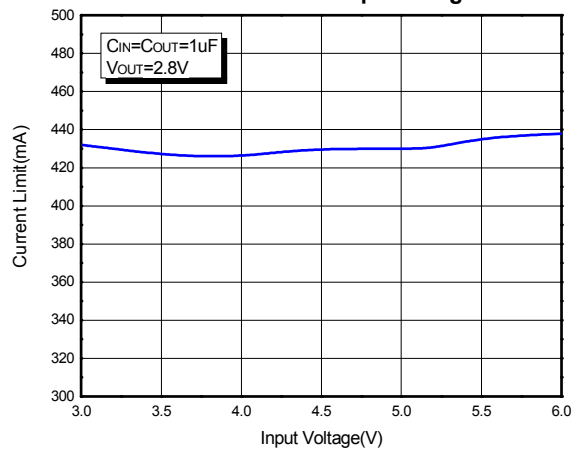
PSRR



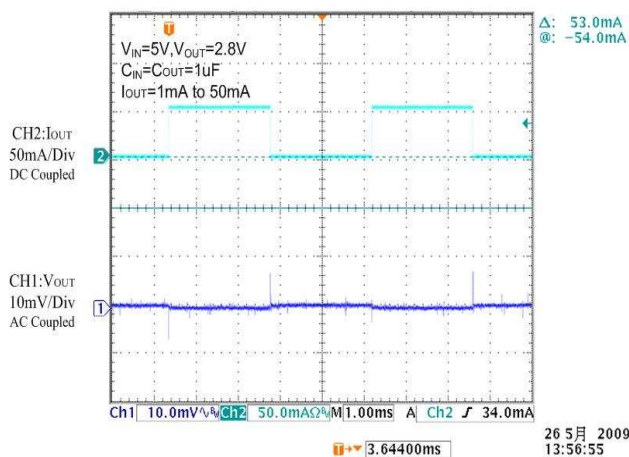
EN Pin Shutdown Threshold Vs. Temperature



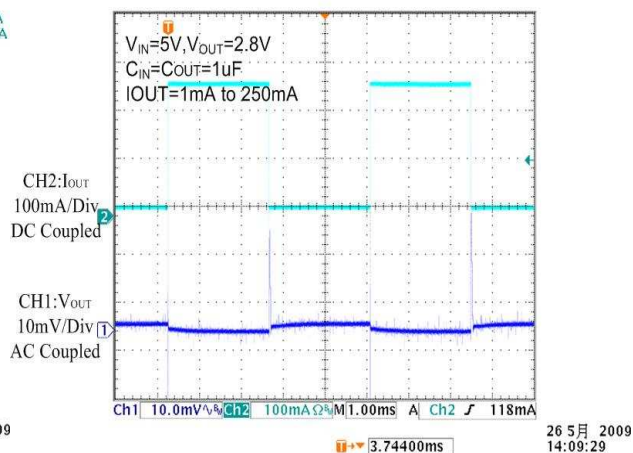
Current Limit Vs. Input Voltage



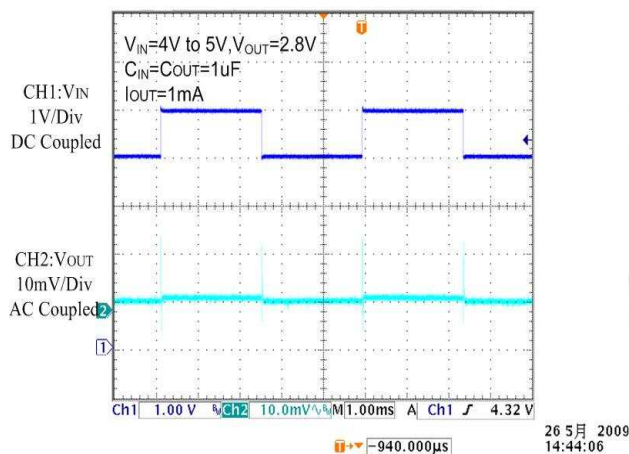
Load Transient Response



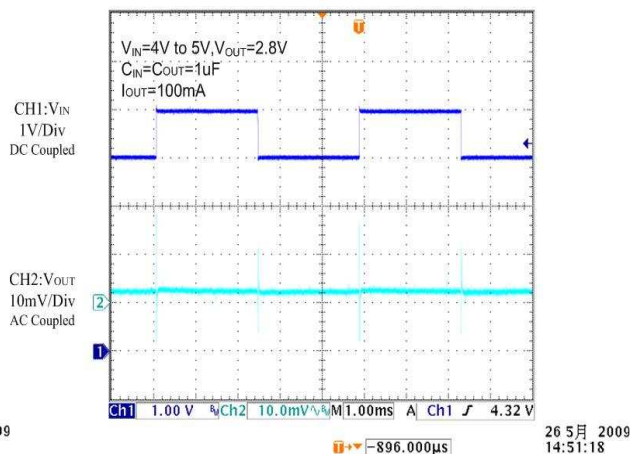
Load Transient Response



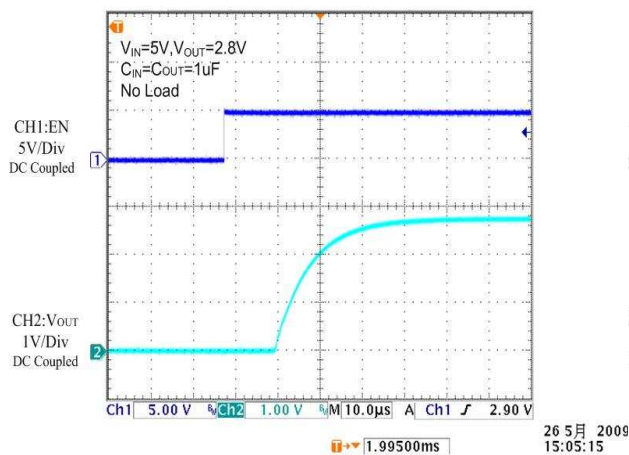
Line Transient Response



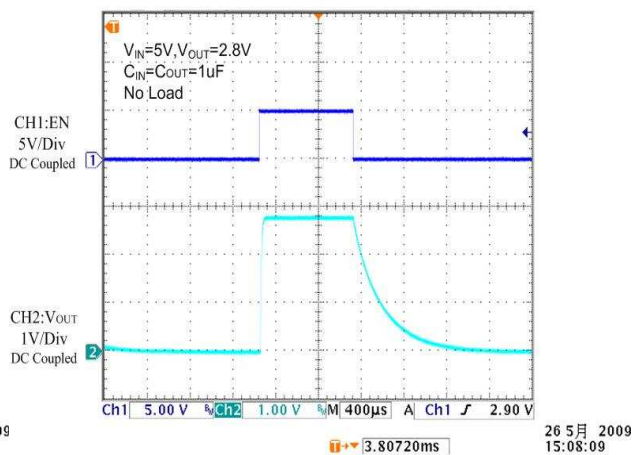
Line Transient Response

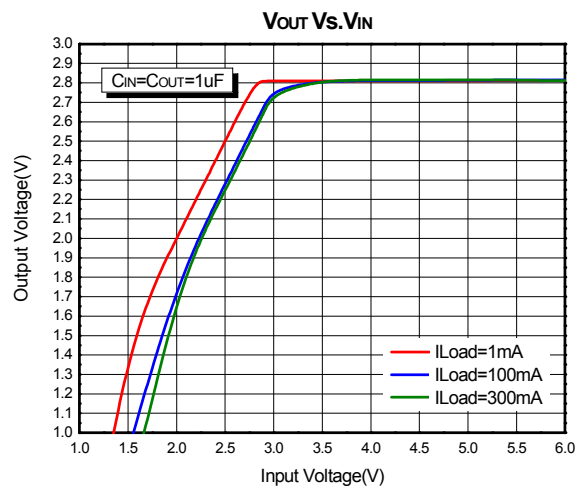


Start Up



EN Pin Shutdown Response





## Applications Information

Like any low-dropout regulator, the external capacitors used with the LR9198 must be carefully selected for regulator stability and performance. Using a capacitor whose value is  $> 1\mu\text{F}$  on the LR9198 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 LR9198 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  $> 25\text{m}\Omega$  on the LR9198 output ensures stability. The LR9198 still works well with output capacitor of other types due to the wide stable ESR range. 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 BL9198 and returned to a clean analog ground.

### Enable Function

The LR9198 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 shut-

down mode when the voltage on the EN pin falls below 0.4 volts. For to protect the system, the LR9198 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 LR9198. When the operation junction temperature exceeds  $165^{\circ}\text{C}$ , the OTP circuit starts the thermal shutdown function turn the pass element off. The pass element turns on again after the junction temperature cools by  $30^{\circ}\text{C}$ .

For continue operation, do not exceed absolute maximum operation junction temperature  $125^{\circ}\text{C}$ . The power dissipation definition in device is:

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

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:

$$P_D(\text{MAX}) = (T_J(\text{MAX}) - T_A) / \theta_{JA}$$

Where  $T_J(\text{MAX})$  is the maximum operation junction temperature  $125^{\circ}\text{C}$ ,  $T_A$  is the ambient temperature and the  $\theta_{JA}$  is the junction to ambient thermal resistance. For recommended operating conditions specification of LR9198, where  $T_J(\text{MAX})$  is the maximum junction temperature of the die ( $125^{\circ}\text{C}$ ) and  $T_A$  is the maximum ambient temperature. The junction to ambient thermal resistance ( $\theta_{JA}$  is layout dependent)



for SOT-23-5 package is 250°C/W, SC-70-5 package is 333°C/W, 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:

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

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

The maximum power dissipation depends on operating ambient temperature for fixed  $T_J(\text{MAX})$  and thermal resistance  $\theta_{JA}$ . It is also useful to calculate the junction of temperature of the BL9198 under a set of specific conditions. In this example let the Input voltage  $V_{IN} = 3.3\text{V}$ , the output current  $I_O = 300\text{mA}$  and the case temperature  $T_A = 40^\circ\text{C}$  measured by a thermal couple during operation. The power dissipation for the  $V_{OUT} = 2.8\text{V}$  version of the BL9198 can be calculated as:

$$P_D = (3.3\text{V} - 2.8\text{V}) \times 300\text{mA} + 3.6\text{V} \times 100\mu\text{A} = 150\text{mW}$$

And the junction temperature,  $T_J$ , can be calculated as follows:

$$T_J = T_A + P_D \times \theta_{JA} = 40^\circ\text{C} + 0.15\text{W} \times 250^\circ\text{C/W} = 40^\circ\text{C} + 37.5^\circ\text{C} = 77.5^\circ\text{C} < T_J(\text{MAX}) = 125^\circ\text{C}$$

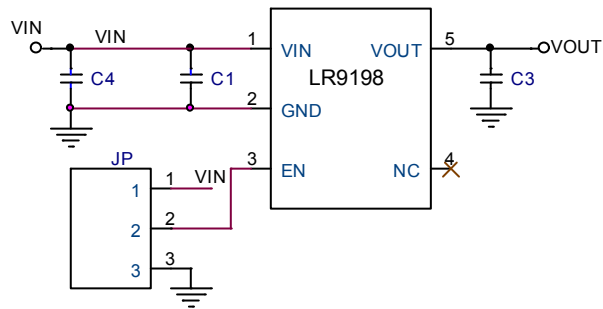
For this operating condition,  $T_J$  is lower than the absolute maximum operating junction temperature,  $125^\circ\text{C}$ , so it is safe to use the LR9198 in this configuration.

### **Layout considerations**

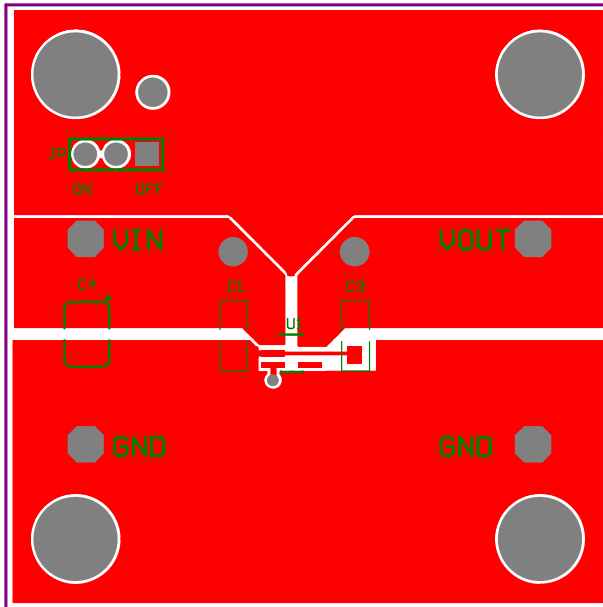
To improve ac performance such as PSRR, output noise, and transient response, it is recommended that the PCB be designed

with separate ground planes for  $V_{IN}$  and  $V_{OUT}$ , with each ground plane connected only at the GND pin of the device.

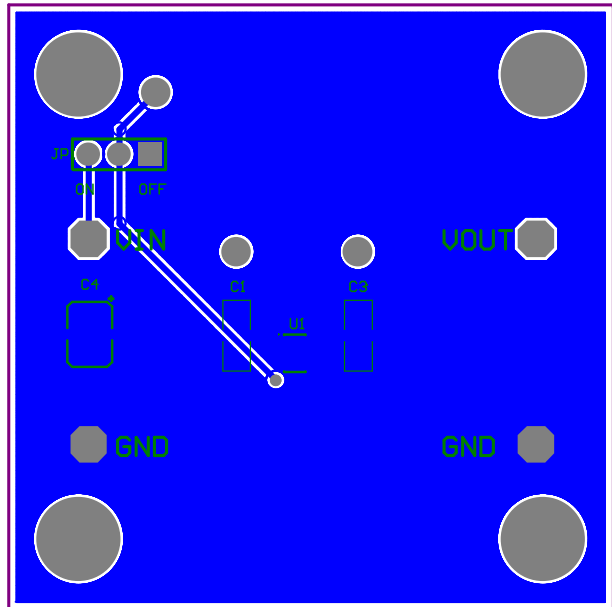
## LR9198-2.8V Layout Circuit



TOP Layer Layout

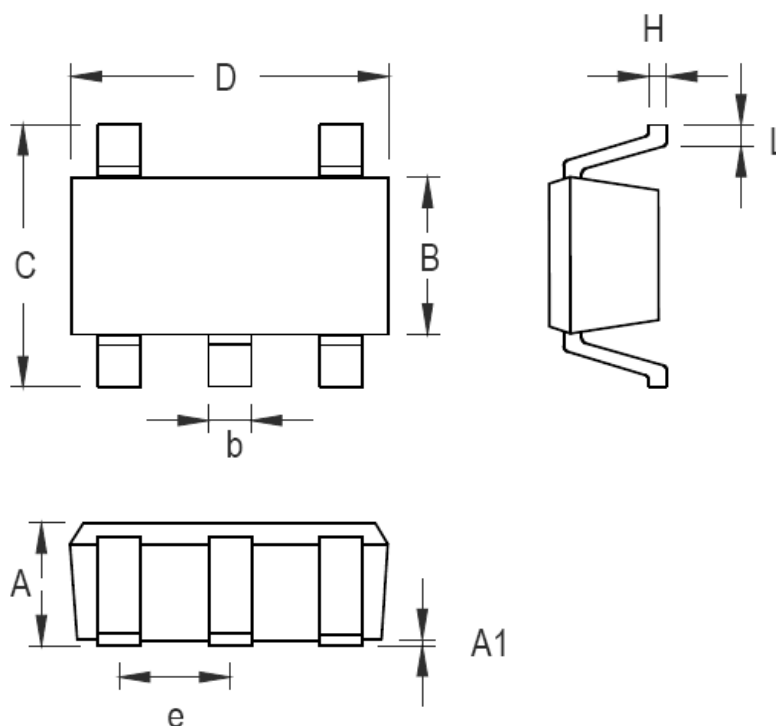


BOTTOM Layer Layout

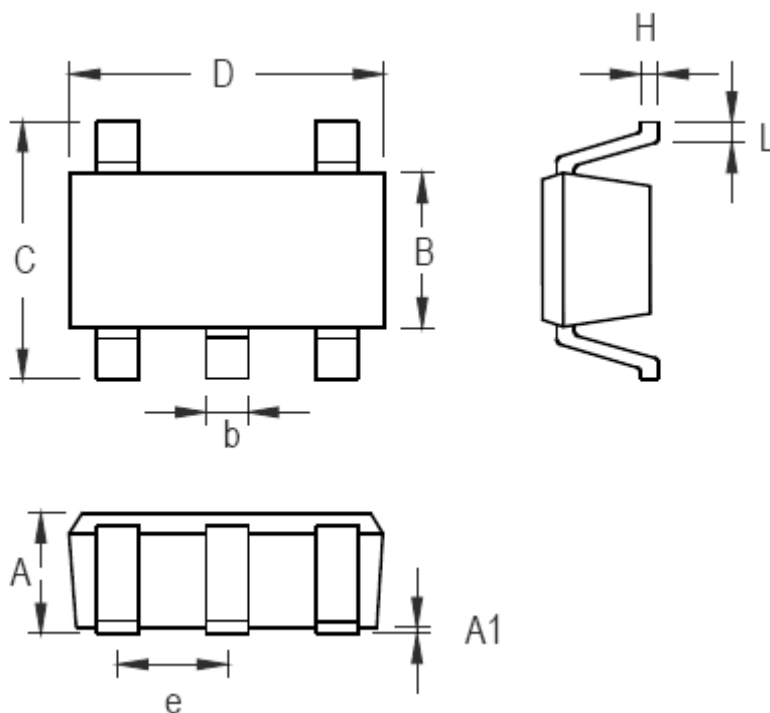


## Package Description

### SC-70-5 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

**SOT-23-5 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