

# Ultra Low Noise 300mA Dual LDO Regulator with POR, NMOS Driver and Requiring No Bypass Capacitor

## General Description

RT9014/A is a dual channel, low noise, and low dropout with the sourcing ability up to 300mA, an open drain driver and power-on reset function. The open-drain output is capable of sinking 150mA for LED backlighting applications.

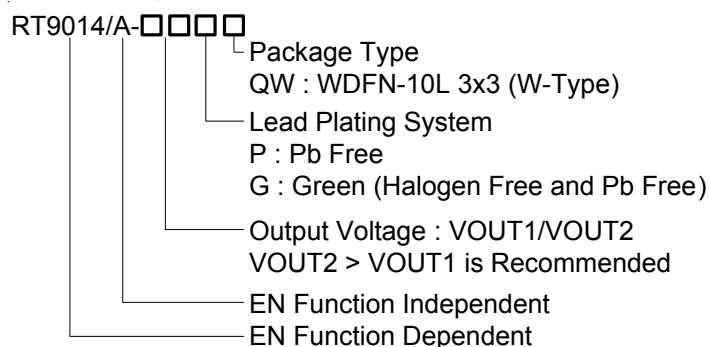
The range of output voltage is from 1.2V to 3.5V by operating from 2.5V to 5.5V input.

The RT9014/A offers 2% accuracy, extremely low dropout voltage (240mV @ 300mA), and extremely low ground current, only 27µA per LDO. The shutdown current is near zero current which is suitable for battery-power devices. Other features include current limiting, over temperature, output short circuit protection.

The RT9014/A is short circuit thermal folded back protected. The IC 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 RT9014/A can operate stably with very small ceramic output capacitors, reducing required board space and component cost. The RT9014/A is available in fixed output voltages in the WDFN-10L 3x3 package.

## Ordering Information



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

- Wide Operating Voltage Ranges : 2.5V to 5.5V
- Low-Noise for RF Application
- No Noise Bypass Capacitor Required
- Fast Response in Line/Load Transient
- TTL-Logic-Controlled Shutdown Input
- Low Temperature Coefficient
- Dual LDO Outputs (300mA/300mA)
- 1 Open-Drain Driver
- Ultra-low Quiescent Current 27µA/LDO
- High Output Accuracy 2%
- Short Circuit Protection
- Thermal Shutdown Protection
- Current Limit Protection
- Short Circuit Thermal Folded Back Protection
- Tiny 10-Lead WDFN Package
- 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

## Available Voltage Version

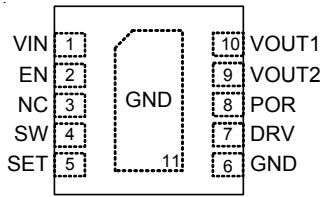
Code	Voltage	Code	Voltage	Code	Voltage
A	3.5	B	1.3	C	1.2
D	1.85	E	2.1	F	1.5
G	1.8	H	2	J	2.5
K	2.6	L	2.7	M	2.8
N	2.85	P	3	Q	3.1
R	3.2	S	3.3	T	2.65
V	2.9	W	1.6	Y	1.9

## Marking Information

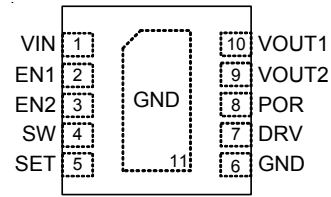
For marking information, contact our sales representative directly or through a Richtek distributor located in your area.

Pin Configuration

(TOP VIEW)

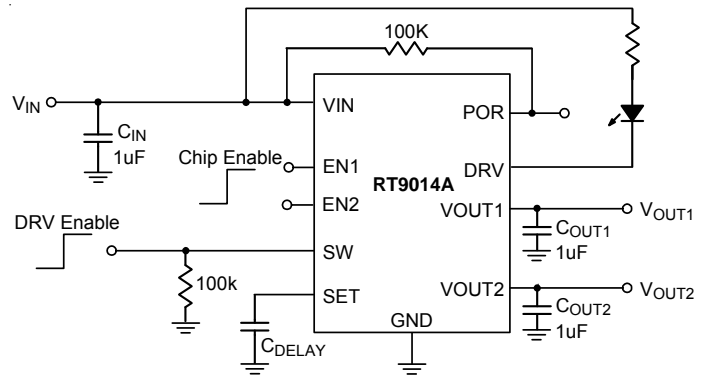
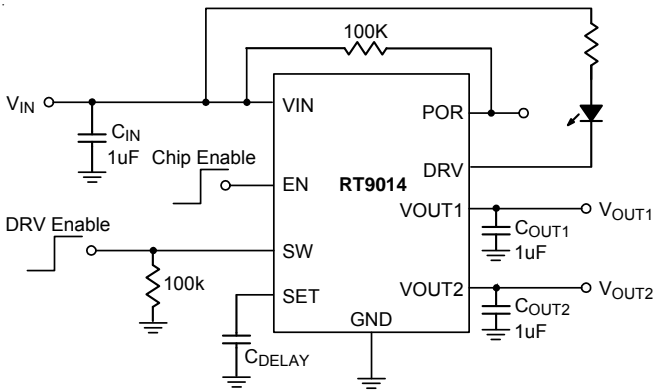


RT9014



RT9014A

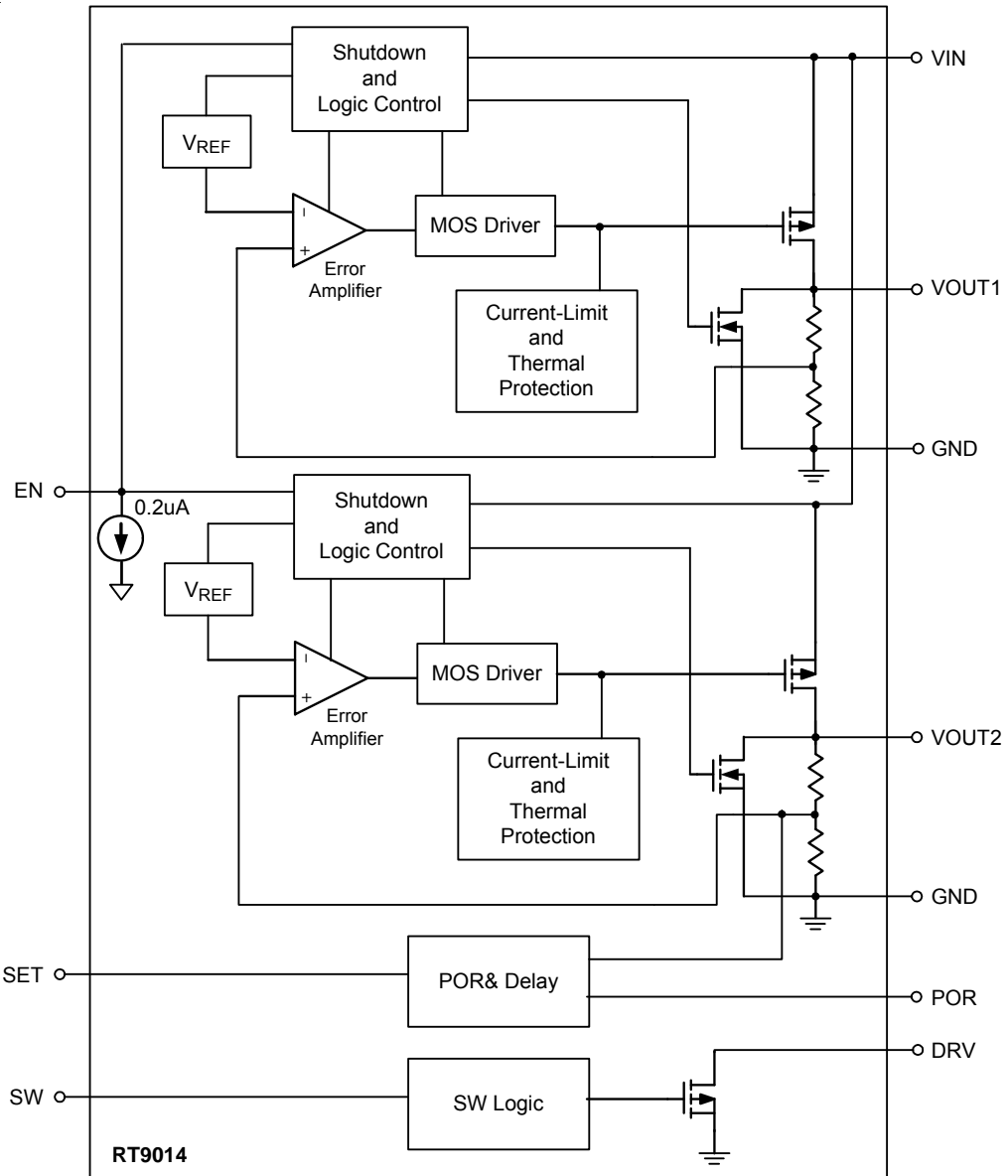
Typical Application Circuit



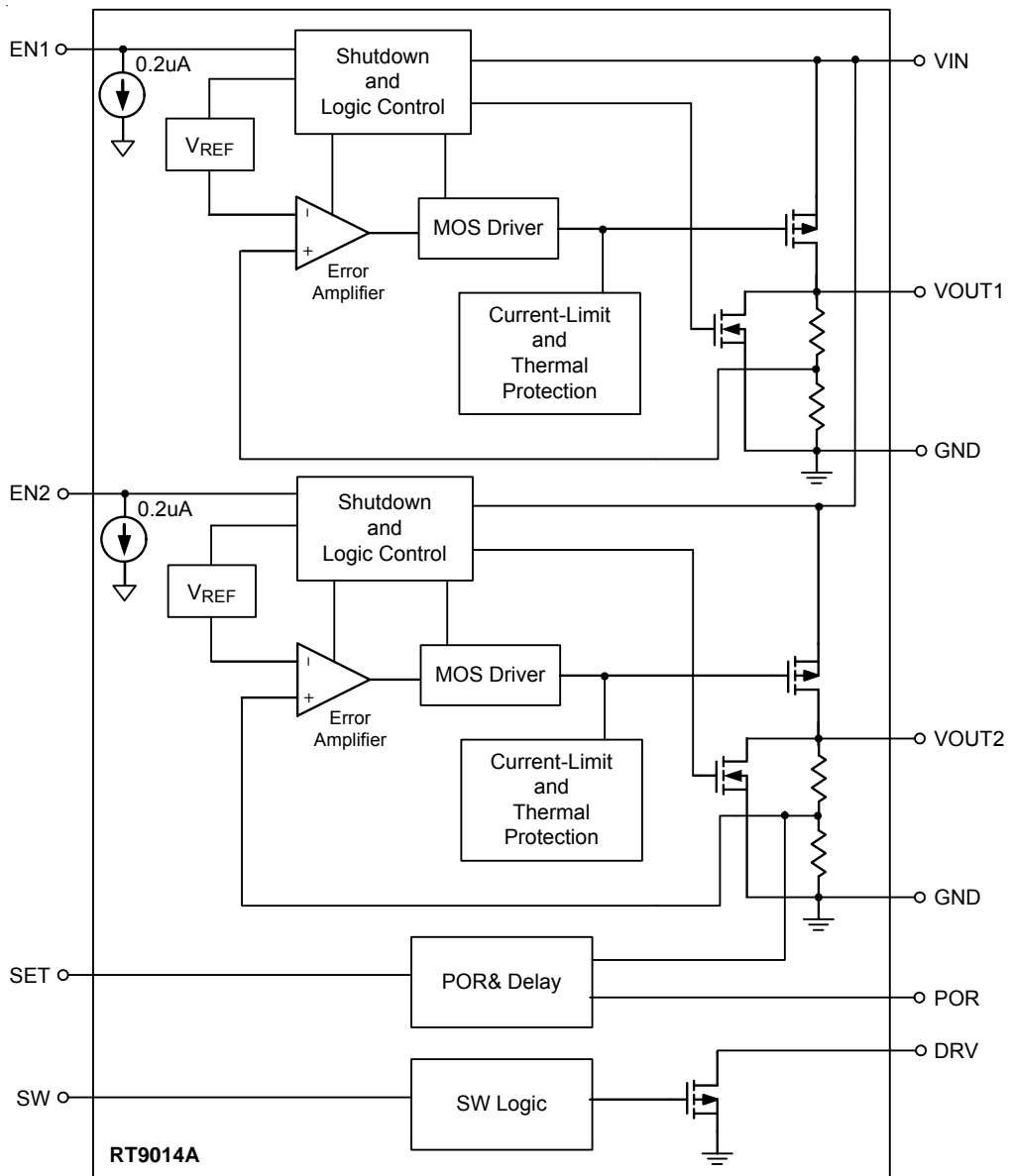
Functional Pin Description

Pin No.		Pin Name	Pin Function
RT9014-□□PQW	RT9014A-□□		
1	1	VIN	Supply input.
2	--	EN	Chip enable (Active high).
--	2	EN1	Chip enable 1 (Active high).
--	3	EN2	Chip enable 2 (Active high).
3	--	NC	No internal connection pin.
4	4	SW	Active high signal drives open-drain N-MOSFET. Note that this pin is high impedance. There should be a pull low 100kΩ resistor connected to GND when the control signal is floating.
5	5	SET	Delay set input: Connect external capacitor to GND to set the internal delay for the POR output. When left open, there is no delay. This pin cannot be grounded.
6	6	GND	Common ground.
7	7	DRV	Open-Drain output: Capable of sinking 150mA.
8	8	POR	Power-On reset output: Open-drain output. Active low indicates an output under-voltage condition on regulator 2.
9	9	VOUT2	Channel 2 output voltage
10	10	VOUT1	Channel 1 output voltage
11 (Exposed Pad)	11 (Exposed Pad)	GND	The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.

**Functional Block Diagram**



*To be continued*



**Absolute Maximum Ratings** (Note 1)

- Supply Input Voltage ----- 6V
- Other I/O Pin Voltages ----- 6V
- Power Dissipation,  $P_D$  @  $T_A = 25^\circ\text{C}$   
 WDFN-10L 3x3 ----- 0.926W
- Package Thermal Resistance (Note 2)  
 WDFN-10L 3x3,  $\theta_{JA}$  ----- 108°C/W
- Junction Temperature ----- 150°C
- Lead Temperature (Soldering, 10 sec.) ----- 260°C
- Storage Temperature Range ----- -65°C to 150°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
- Enable Input Voltage ----- 0V to 5.5V
- Junction Temperature Range ----- -40°C to 125°C
- Ambient Temperature Range ----- -40°C to 85°C

**Electrical Characteristics**

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage	$V_{IN}$	$V_{IN} = 2.5V$ to $5.5V$	2.5	--	5.5	V
Dropout Voltage (Note 5)	$V_{DROP}$	$I_{OUT} = 150\text{mA}$	--	120	--	mV
		$I_{OUT} = 300\text{mA}$	--	240	--	mV
Output Voltage Range	$V_{OUT}$		1.2	--	3.5	V
$V_{OUT}$ Accuracy	$\Delta V$	$I_{OUT} = 1\text{mA}$	-2	--	+2	%
Line Regulation	$\Delta V_{LINE}$	$V_{IN} = (V_{OUT} + 0.3V)$ to $5.5V$ or $V_{IN} > 2.5V$ , whichever is larger	--	--	0.2	%/V
Load Regulation	$\Delta V_{LOAD}$	$1\text{mA} < I_{OUT} < 300\text{mA}$	--	--	0.6	%
Current Limit		$R_{LOAD} = 1\Omega$	330	450	700	mA
Quiescent Current	$I_Q$	$V_{EN} > 1.5V$	--	58	80	$\mu\text{A}$
Shutdown Current	$I_{Q\_SD}$	$V_{EN} < 0.4V$	--	--	1	$\mu\text{A}$
EN Threshold	$V_{IH}$	$V_{IN} = 2.5V$ to $5.5V$ , power on	1.5	--	--	V
	$V_{IL}$	$V_{IN} = 2.5V$ to $5.5V$ , shutdown	--	--	0.4	
Output Voltage TC			--	100	--	ppm/ $^\circ\text{C}$
Thermal Shutdown	$T_{SD}$		--	170	--	$^\circ\text{C}$
Thermal Shutdown Hysteresis	$\Delta T_{SD}$		--	40	--	$^\circ\text{C}$

*To be continued*

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
PSRR $I_{LOAD} = 10mA$	PSRR	f = 100Hz	--	65	--	dB
		f = 1kHz	--	60	--	dB
		f = 10kHz	--	50	--	dB
PSRR $I_{LOAD} = 150mA$	PSRR	f = 100Hz	--	65	--	dB
		f = 1kHz	--	50	--	dB
		f = 10kHz	--	50	--	dB
<b>Power Good</b>						
Reset Threshold	$V_{THL}$	Low threshold, % of nominal $V_{OUT2}$ (Flag on)	85	90	93	%
	$V_{THH}$	High threshold, % of nominal $V_{OUT2}$ (Flag off)	92	95	98	%
POR Output Logic Low Voltage	$V_{OL}$	$I_{LOW} = 250\mu A$	--	0.02	0.1	V
POR Leakage Current	$I_{POR}$	Flag off	-1	0.01	1	$\mu A$
Set pin current source		$V_{SET} = 0$	0.60	1.25	1.70	$\mu A$
Set pin threshold		POR = high	--	1.4	--	V
<b>DRV output</b>						
Voltage Low		$I_{DRV} = 150mA$	--	0.2	0.5	V
Leakage current		$I_{DRV} = 0mA, V_{DRV} = 5V, SW = 0V$	-1	0.01	1	$\mu A$
SW input current		$V_{IL} < 0.6V$ (DRV shutdown)	-1	0.01	1	$\mu A$
		$V_{IH} > 2.5V$ (DRV enable)	-1	0.01	1	$\mu A$
SW input voltage	$V_{IL}$	Logic low	--	--	0.4	V
	$V_{IH}$	Logic high	1.5	--	--	V

**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.

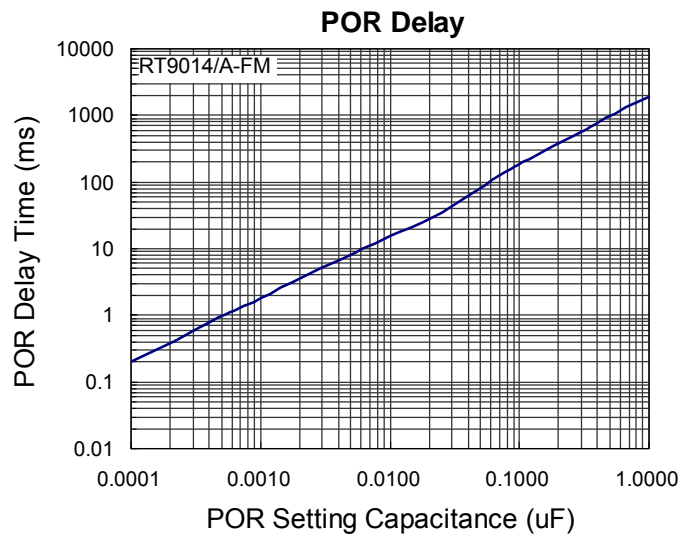
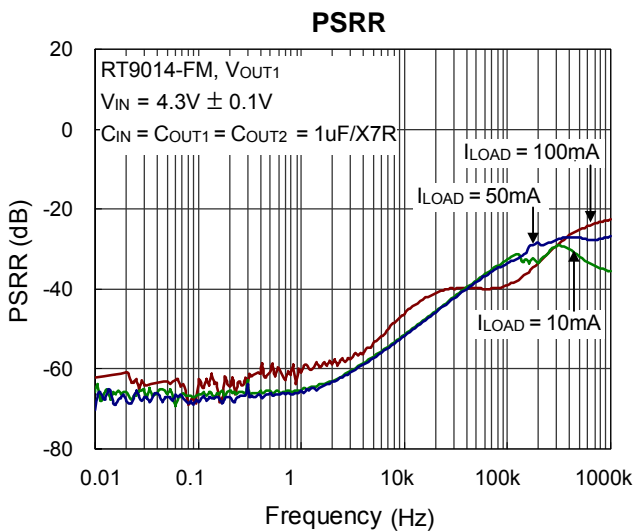
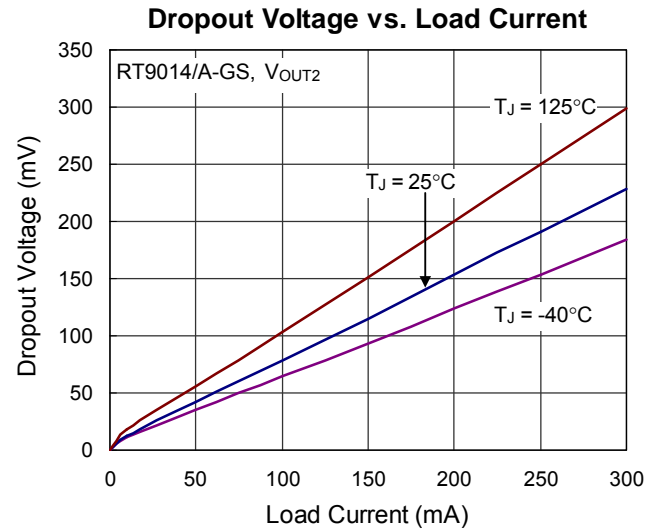
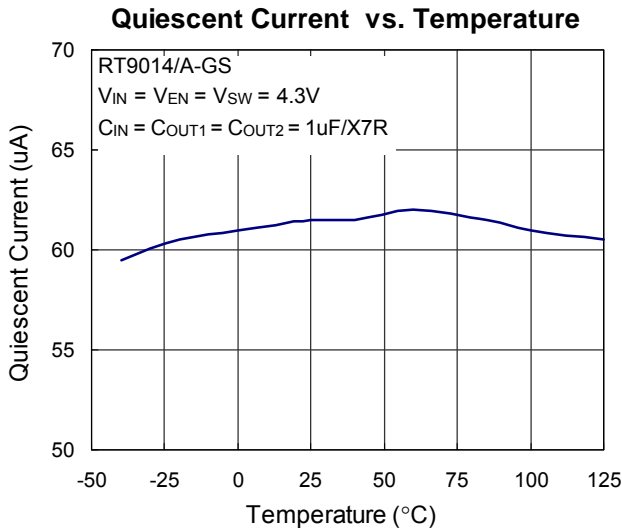
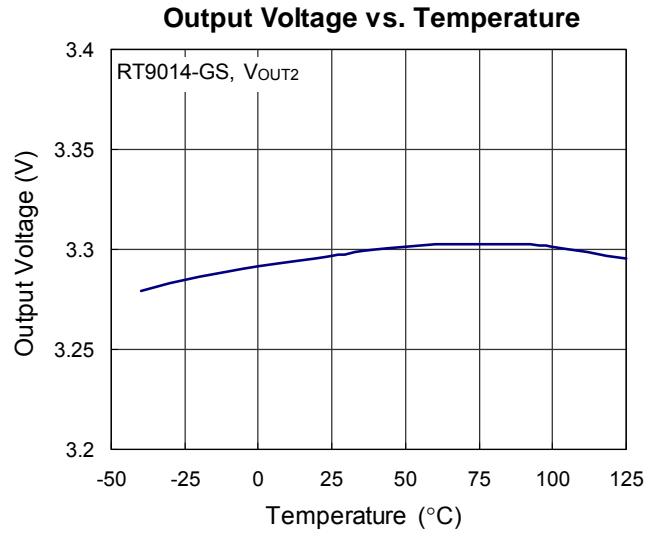
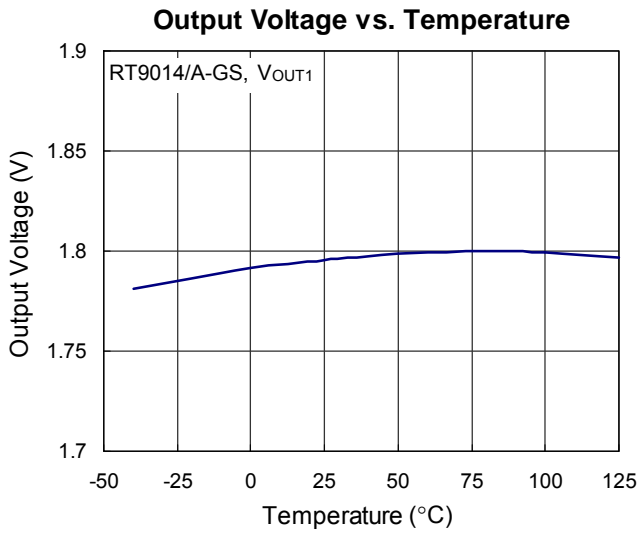
**Note 2.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ C$  on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

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

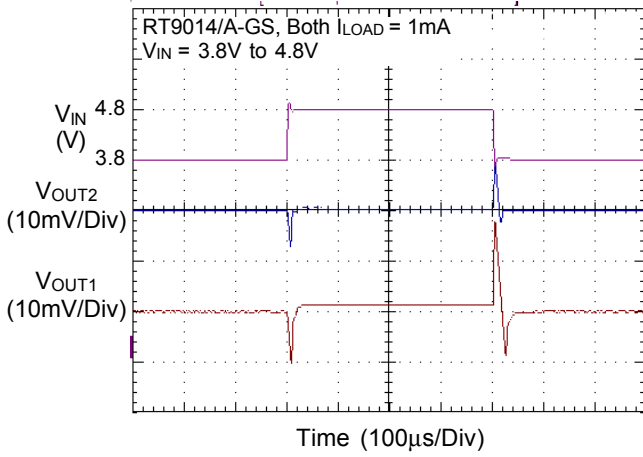
**Note 4.** The device is not guaranteed to function outside its operating conditions.

**Note 5.** The dropout voltage is defined as  $V_{IN} - V_{OUT}$ , which is measured when  $V_{OUT}$  is  $V_{OUT(NORMAL)} - 100mV$ .

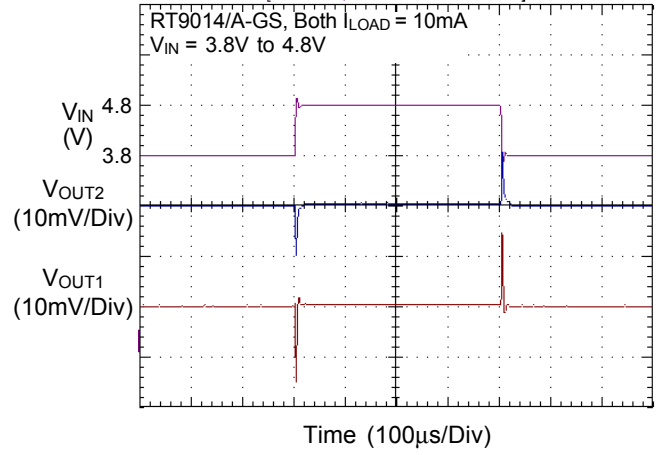
**Typical Operating Characteristics**



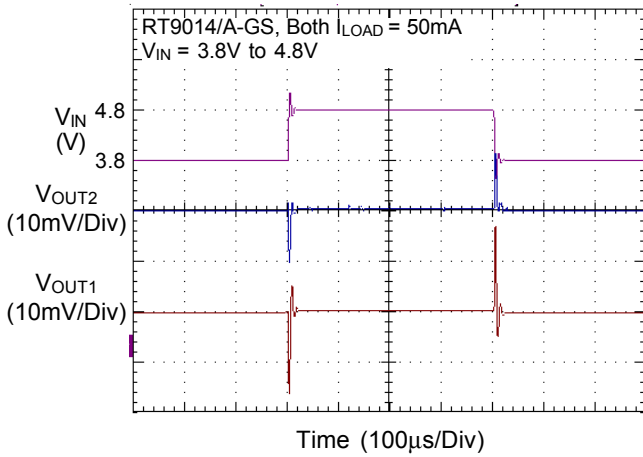
Line Transient Response



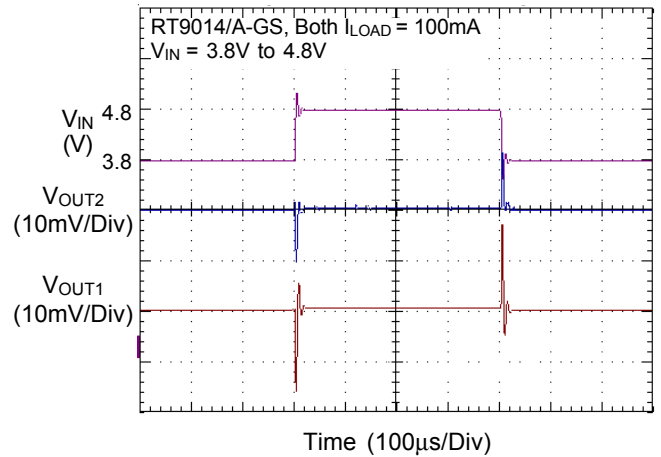
Line Transient Response



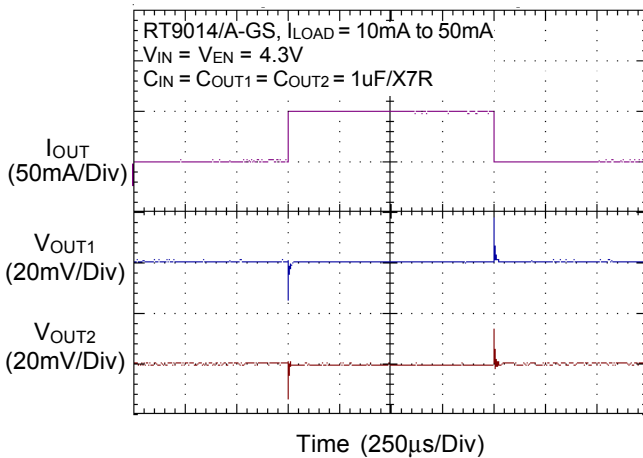
Line Transient Response



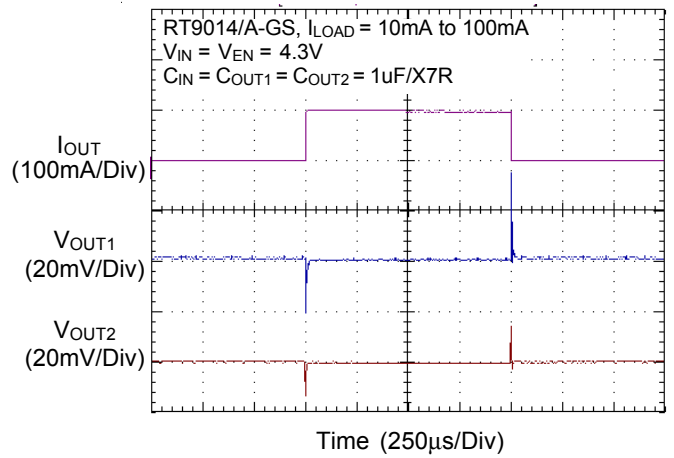
Line Transient Response



Load Transient Response

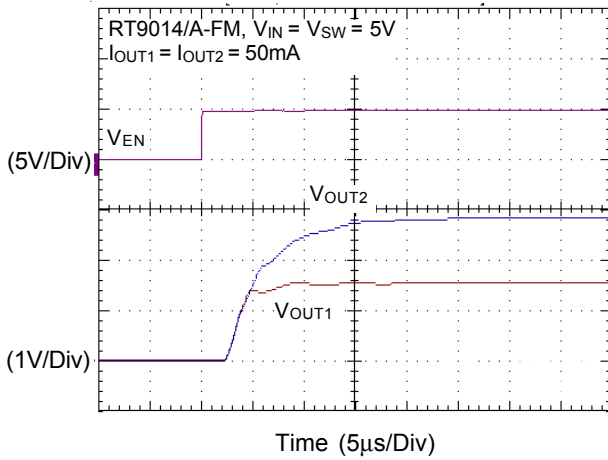


Load Transient Response

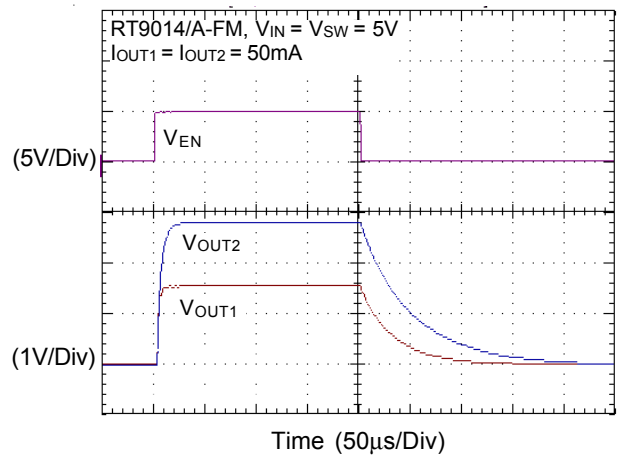




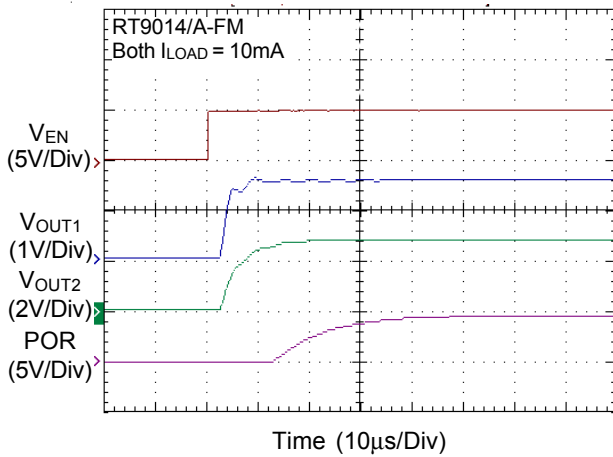
**Start Up**



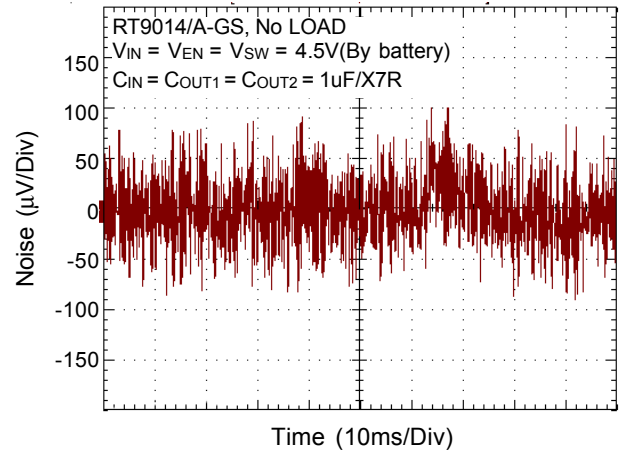
**EN Pin Shutdown Response**



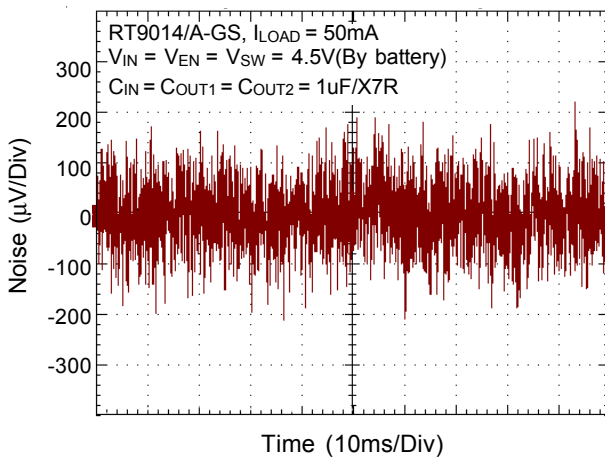
**Power-On**



**Noise**



**Noise**



### Applications Information

Like any low-dropout regulator, the external capacitors used with the RT9014/A must be carefully selected for regulator stability and performance. Using a capacitor whose value is > 1μF on the RT9014/A 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 RT9014/A 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 1μF with ESR is > 20mΩ on the RT9014/A output ensures stability. The RT9014/A 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 VOUT pin of the RT9014/A and returned to a clean analog ground.

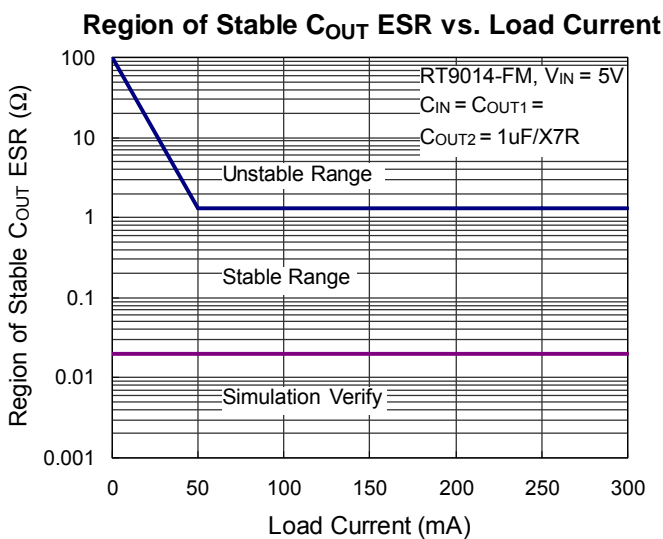


Figure 1. Stable Cout ESR Range

### Thermal Considerations

Thermal protection limits power dissipation in RT9014/A. When the operation junction temperature exceeds 170°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 40°C. RT9014/A lowers its OTP trip level from 170°C to 110°C when output short circuit occurs (VOUT < 0.4V) as shown in Figure 2. It limits IC case temperature under 100°C and provides maximum safety to customer while output short circuit occurring.

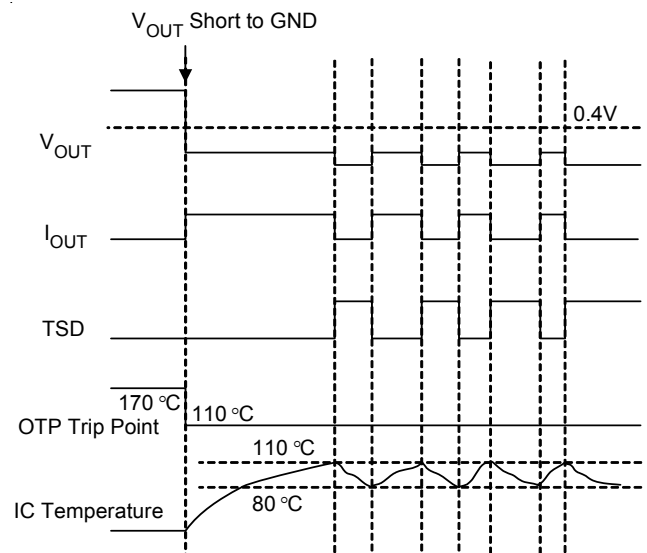


Figure 2. Short Circuit Thermal Folded Back Protection when Output Short Circuit Occurs (Patent)

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,  $T_A$  is the ambient temperature and the  $\theta_{JA}$  is the junction to ambient thermal resistance.

For recommended operating conditions specification of RT9014/A, the maximum junction temperature is 125°C. The junction to ambient thermal resistance ( $\theta_{JA}$  is layout dependent) for WDFN-10L 3x3 package is 108°C/W on the standard JEDEC 51-3 single-layer thermal test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated by following formula :

$$P_{D(MAX)} = ( 125^\circ\text{C} - 25^\circ\text{C} ) / 108 = 0.926\text{W for WDFN-10L 3x3 packages}$$

The maximum power dissipation depends on operating ambient temperature for fixed  $T_{J(MAX)}$  and thermal resistance  $\theta_{JA}$ . For RT9014/A packages, the Figure 3 of derating curves allows the designer to see the effect of rising ambient temperature on the maximum power allowed.

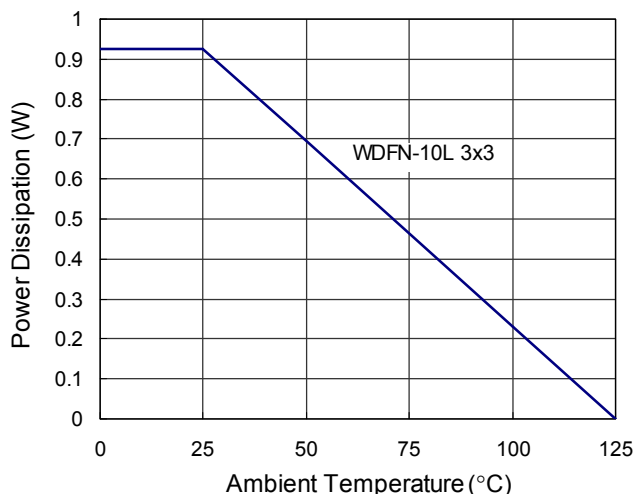
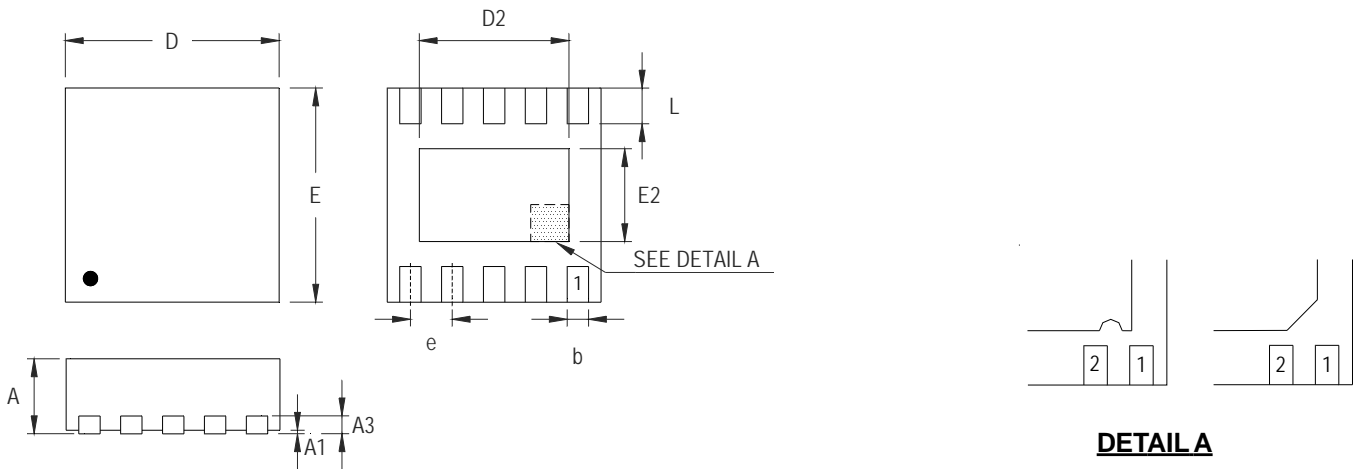


Figure 3. Derating Curves for RT9014/A Packages

## Outline Dimension



### 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	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	2.300	2.650	0.091	0.104
E	2.950	3.050	0.116	0.120
E2	1.500	1.750	0.059	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

### W-Type 10L DFN 3x3 Package

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