

3A, Ultra-Low Dropout Voltage Regulator

General Description

The RT9059A is a high performance positive voltage regulator designed for use in applications requiring very low input voltage and very low dropout voltage at up to 3A. It operates with a VIN as low as 1V and VDD voltage 3V with programmable output voltage as low as 0.8V. The RT9059A features ultra-low dropout, ideal for applications where VOUT is very close to VIN. Additionally, it has an enable pin to further reduce power dissipation while shutdown. The RT9059A provides excellent regulation over variations in line, load and temperature. The RT9059A provides a power good signal to indicate if the voltage level of VO reaches 90% of its rating value.

Ordering Information

RT9059A□□

- Package Type
QW : WDFN-10L 3x3 (W-Type)
- Lead Plating System
G : Green (Halogen Free and Pb Free)

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.

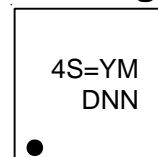
Features

- Output Current up to 3A
- High Accuracy ADJ Voltage 1.5%
- Dropout Voltage 350mV @ 3A Typically
- VOUT Power Good Signal
- VOUT Pull Low Resistance when Disable
- Current-Limit Protection
- Thermal Shutdown Protection
- RoHS Compliant and Halogen Free

Applications

- Notebook PC Applications
- Motherboard Applications

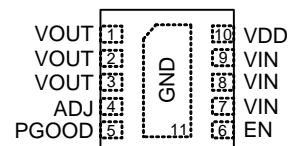
Marking Information



4S= : Product Code
YMDNN : Date Code

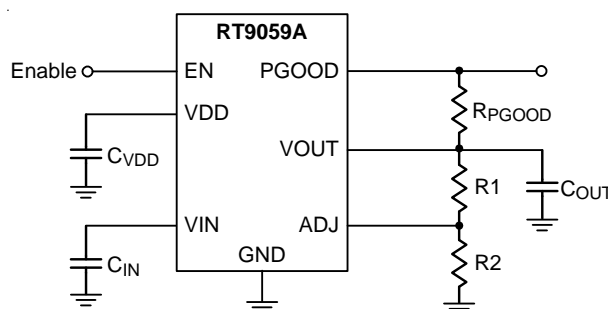
Pin Configuration

(TOP VIEW)



WDFN-10L 3x3

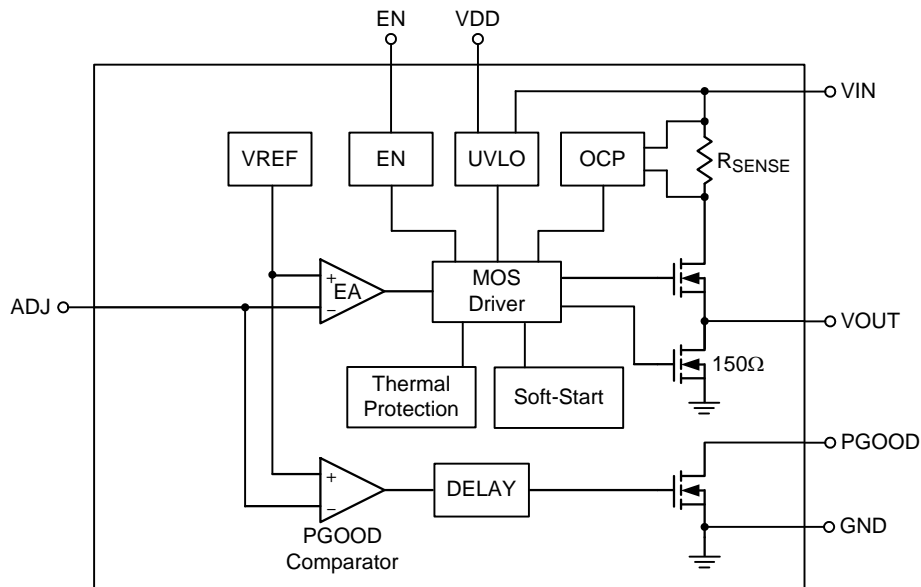
Simplified Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1, 2, 3	VOUT	Output voltage.
4	ADJ	Output voltage setting. $V_{OUT} = V_{REF} \times (R1 + R2) / R2$.
5	PGOOD	Power good open-drain output.
6	EN	Enable control input.
7, 8, 9	VIN	Supply voltage input.
10	VDD	Supply voltage of control circuit.
11 (Exposed Pad)	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.

Functional Block Diagram



Operation

The RT9059A is a high performance positive voltage regulator designed for use in very low input voltage and very low dropout voltage with high output current up to 3A.

Output Transistor

The RT9059A includes a built-in low dropout N-MOSFET output transistor for low input voltage and high output current applications.

Error Amplifier

The Error Amplifier compares output feedback voltage from an internal feedback voltage divider or from ADJ pin to an internal reference voltage and controls the N-MOSFET gate voltage to maintain output voltage regulation.

Soft-Start

The RT9059A provides soft-start function to prevent large in-rush current during power on period.

Current Limit and Over-Temperature Protection

The RT9059A provides a current limit function to prevent damage during output over-load or short-circuit conditions. The output current is detected by an internal sensing transistor.

The RT9059A also equips Over-Temperature Protection (OTP) function. When the internal junction temperature exceeds 160°C, OTP function will turn off the N-MOSFET. Once the junction temperature cools down below 90°C, the RT9059A will resume operation automatically.

Absolute Maximum Ratings (Note 1)

• Supply Input Voltage, VIN to GND	
DC -----	-0.3V to 6V
< 10ms -----	-0.3V to 7V
• Control Voltage, VDD to GND	
DC -----	-0.3V to 6V
< 10ms -----	-0.3V to 7V
• Output Voltage, VOUT -----	-0.3V to 6V
• Chip Enable Voltage, EN -----	-0.3V to 6V
• Adjust Voltage, ADJ -----	-0.3V to 6V
• Power Good Voltage, VPGOOD -----	-0.3V to 6V
• Power Dissipation, PD @ TA = 25°C	
WDFN-10L 3x3 -----	3.04W
• Package Thermal Resistance (Note 2)	
WDFN-10L 3x3, θ_{JA} -----	32.8°C/W
WDFN-10L 3x3, θ_{JC} -----	5.9°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 Model) -----	2kV
MM (Machine Model) -----	200V

Recommended Operating Conditions (Note 4)

• Supply Input Voltage, VIN -----	1V to 5V
• Control Voltage, VDD ($V_{DD} > V_{OUT} + 1.5V$) -----	3V to 5.5V
• Junction Temperature Range -----	-40°C to 125°C
• Ambient Temperature Range -----	-40°C to 85°C

Electrical Characteristics

(VDD = 5V, CIN = COUT = 10μF, CVDD = 1μF, TA = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VDD Operation Range	VDD		3	--	5.5	V
VDD POR Threshold	V _{POR_VDD}	VDD rising	2.4	2.7	3	V
VDD POR Falling Hysteresis	ΔV_{POR_VDD}	VDD falling	0.15	0.2	--	V
Input Voltage Range	VIN		1	--	5.5	V
VIN POR Threshold	V _{POR_VIN}	VIN rising	0.7	0.8	0.9	V
VIN POR Falling Hysteresis	ΔV_{POR_VIN}	VIN falling	0.15	0.2	0.25	V
Quiescent Current	I _Q	EN On, no load	--	0.6	1.2	mA
Reference Voltage	VREF		0.788	0.8	0.812	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage Accuracy			-1.5	--	1.5	%
VOOUT Load Regulation	ΔV_{LOAD}	$I_{OUT} = 1mA \text{ to } 3A$, $V_{IN} = V_{OUT} + 1V$	--	0.5	1	%
OUT Line Regulation	ΔV_{LINE}	$V_{DD} = 3.6V \text{ to } 5.5V$, $V_{IN} = V_{OUT} + 1V \text{ to } 5V$, $I_{OUT} = 1mA$	--	0.2	0.6	%
Dropout Voltage	V_{DROP}	$I_{OUT} = 2A$	--	250	350	mV
		$I_{OUT} = 3A$	--	350	450	
Current Limit	I_{LIM}	$V_{IN} = 3.6V$	3.1	3.6	4.2	A
Short Circuit Current	I_{SC}	$V_{OUT} < 0.2V$	1	1.4	1.8	A
VOOUT Pull Low Resistance	R_{PULL}	$V_{EN} = 0V$	--	150	--	Ω
Thermal Shutdown Temperature	T_{SD}		--	160	--	$^{\circ}C$
Thermal Shutdown Recovery Temperature	T_{SDR}		--	90	--	$^{\circ}C$
PGOOD Rising Threshold	V_{TH_PGOOD}	V_{OUT} rising	--	90	--	%
PGOOD Hysteresis	ΔV_{TH_PGOOD}	V_{OUT} falling	--	10	--	%
PGOOD Delay Time			0.2	1	1.5	ms
PGOOD Sink Capability	V_{PGOOD}	$I_{SINK} = 10mA$	--	0.2	0.4	V
EN Input Voltage	Logic-High	V_{IH}	1.2	--	--	V
	Logic-Low	V_{IL}	--	--	0.4	
EN Delay Time			0.3	0.85	1.4	ms
EN Pin Bias Current	I_{EN}	$V_{EN} = 0V$	--	12	--	μA
VDD Pin Shutdown Current	I_{SHDN_VDD}	$V_{EN} = 0V$	--	15	30	μA
VIN Pin Shutdown Current	I_{SHDN_VIN}	$V_{EN} = 0V$, $V_{IN} = 5V$	--	--	1	μA
Inrush Current	I_{INRUSH}	$V_{OUT} = 1.8V$, $C_{OUT} = 10\mu F$, $I_{LOAD} = 1A$	--	0.5	--	A
Soft-Start Time	t_{SS}		1.9	2.8	3.75	ms

Note 1. Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

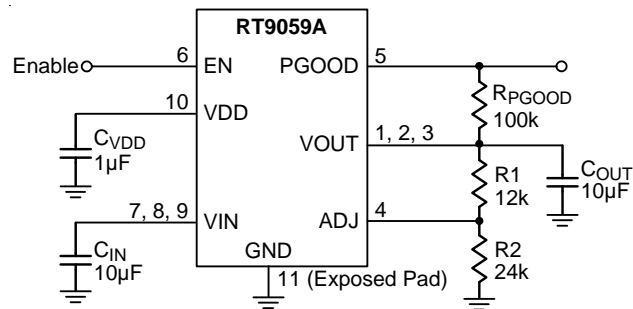
These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at $T_A = 25^{\circ}C$ on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ_{JC} is measured at the exposed pad of the package.

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

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

Typical Application Circuit

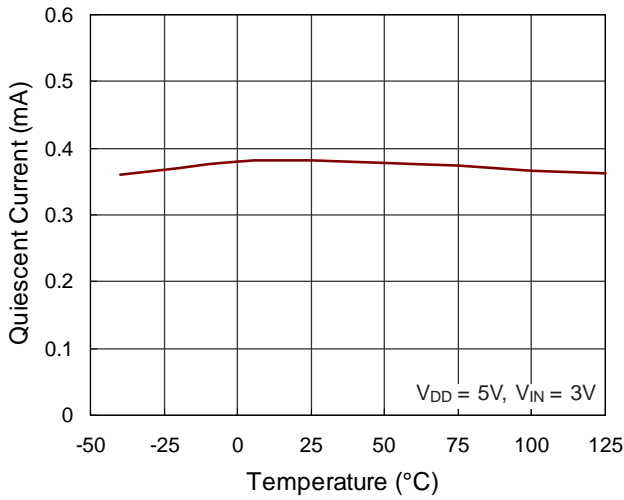


$$V_{OUT} = 0.8 \times (R1 + R2) / R2$$

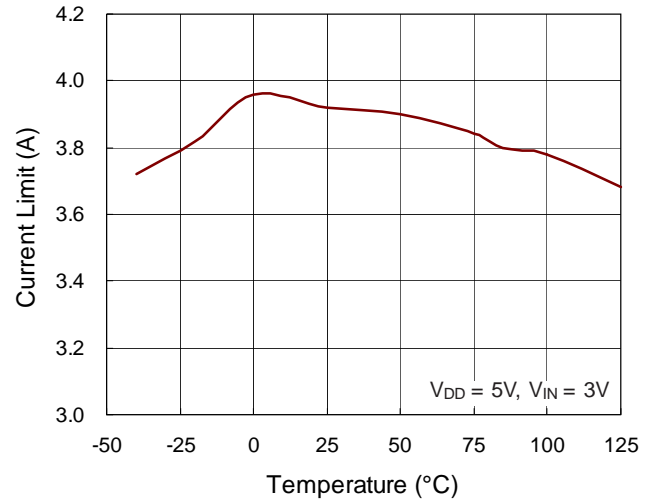
Figure 1. Adjustable Voltage Regulator

Typical Operating Characteristics

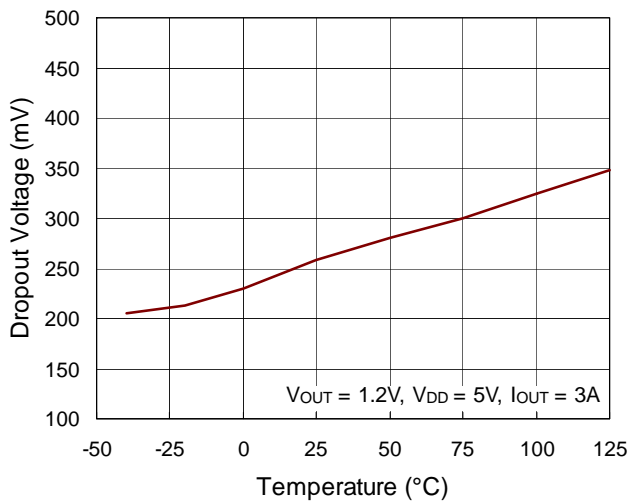
Quiescent Current vs. Temperature



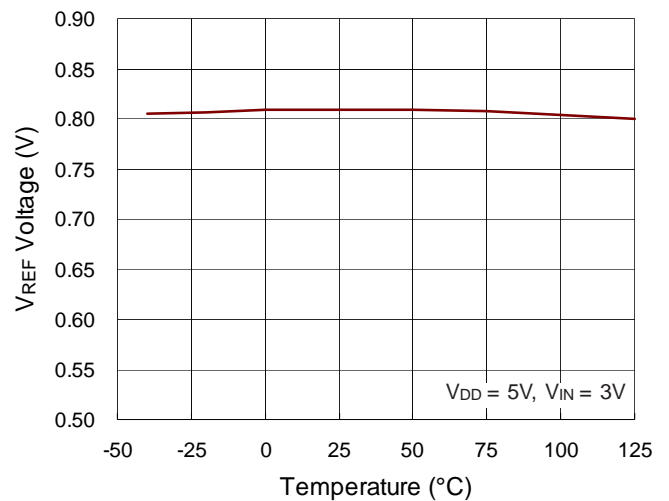
Current Limit vs. Temperature



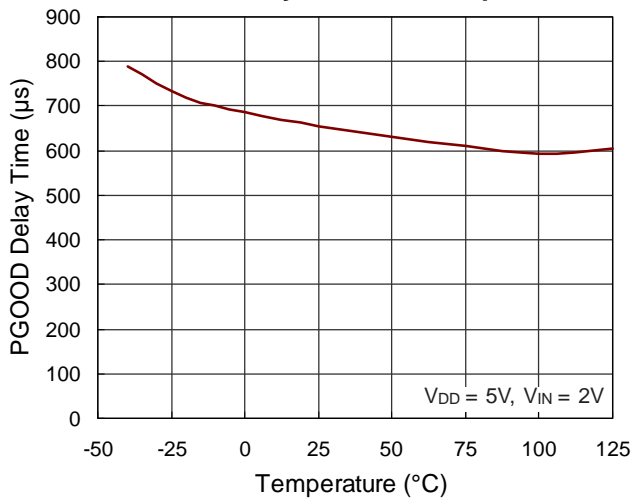
Dropout Voltage vs. Temperature



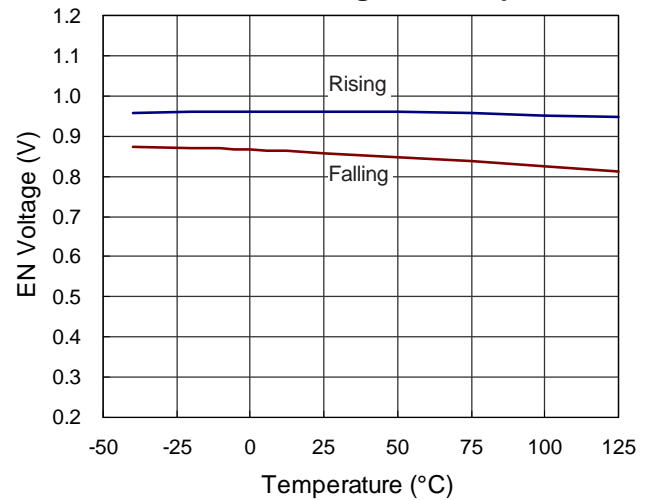
V_{REF} Voltage vs. Temperature



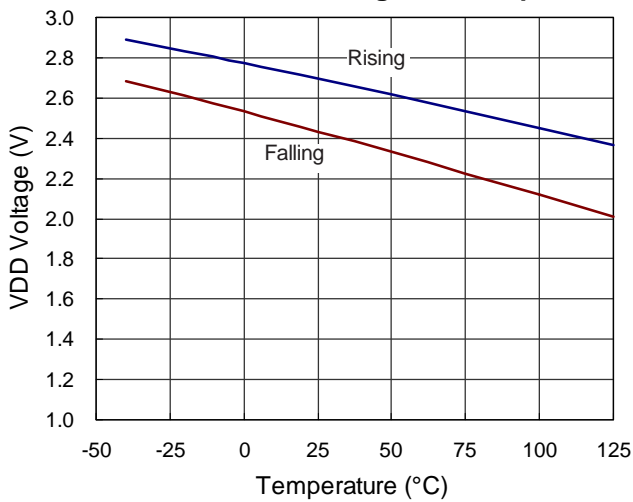
PGOOD Delay Time vs. Temperature



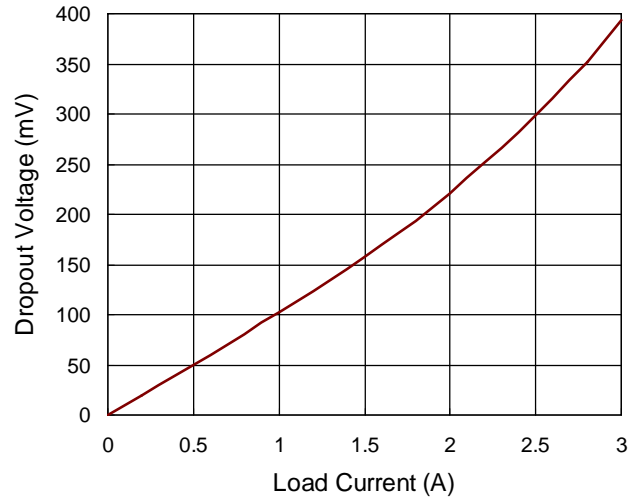
EN Threshold Voltage vs. Temperature



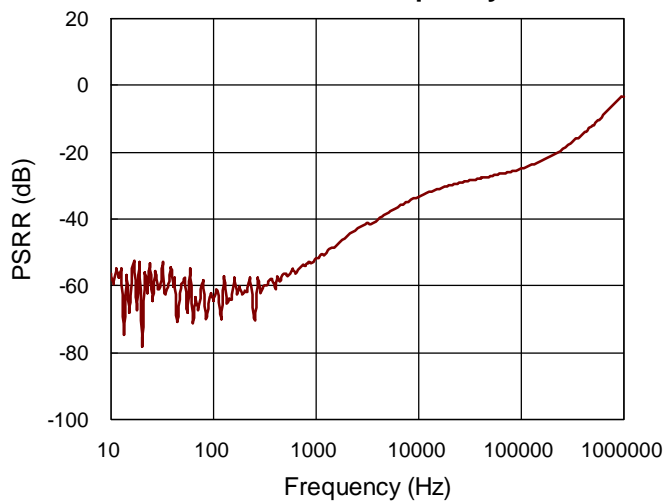
VDD POR Threshold Voltage vs. Temperature



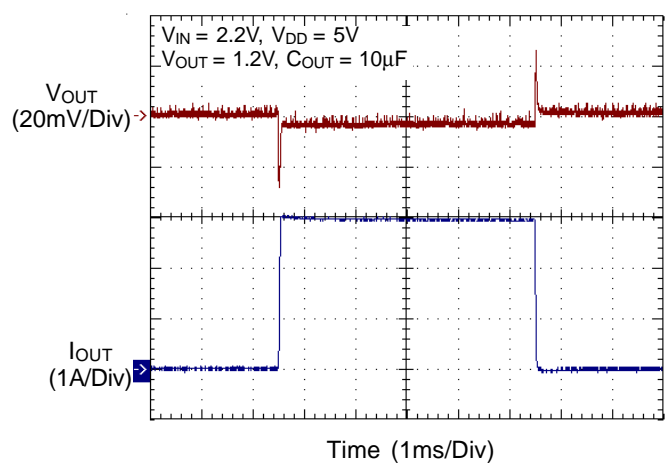
Dropout Voltage vs. Load Current



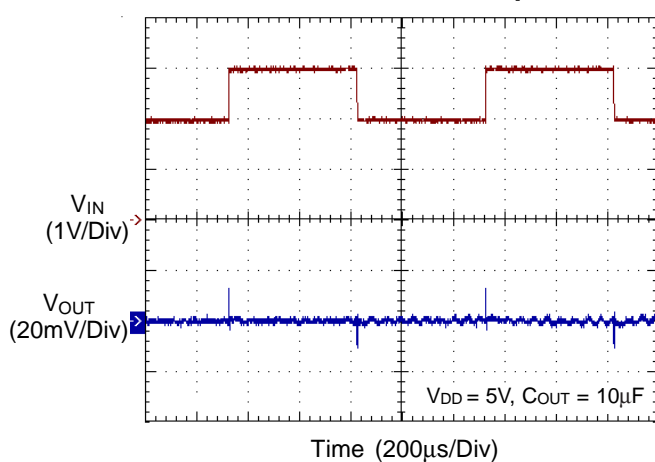
PSRR vs. Frequency



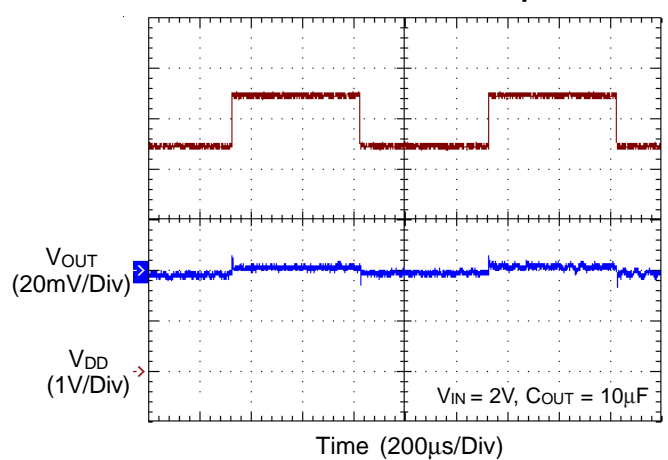
Load Transient Response



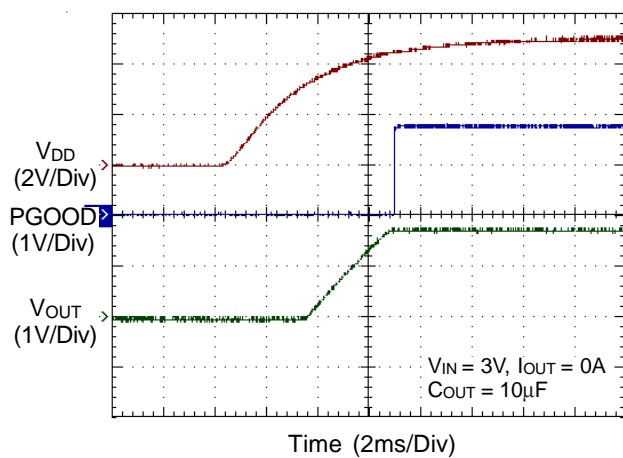
VIN Line Transient Response



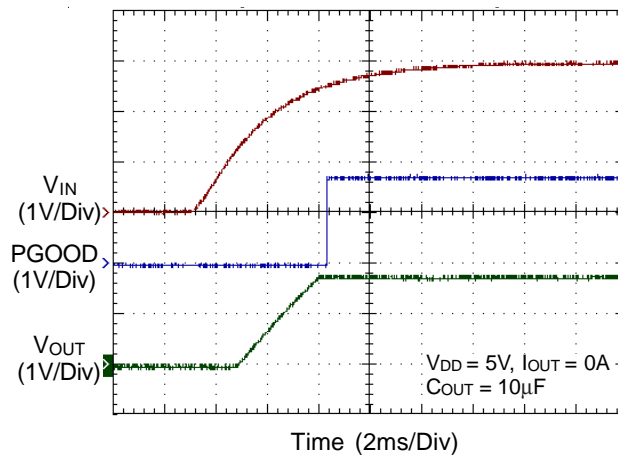
VDD Line Transient Response



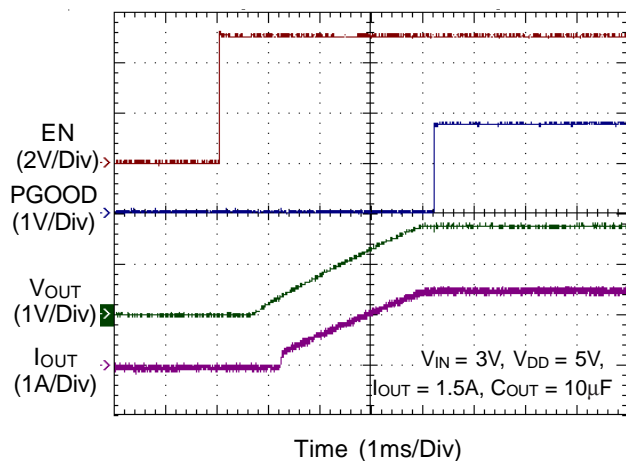
Start Up from V_{DD}



Start Up from V_{IN}



Start Up from Enable and PGOOD Delay



Applications Information

Adjustable Mode Operation

The output voltage of RT9059A is adjustable from 0.8V to V_{IN} by external voltage divider resistors as shown in Typical Application Circuit (Figure 1). The value of resistors R1 and R2 should be more than 10k Ω to reduce the power loss. The output voltage can be calculated by the following equation :

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

where V_{REF} is the reference voltage (0.8V typical).

Enable

The RT9059A goes into shutdown mode when the EN pin is in the logic low condition. During this condition, the pass transistor, error amplifier, and band gap are turned off, reducing the supply current to 1 μ A typical. The RT9059A goes into operation mode when the EN pin is in the logic high condition. If the EN pin is floating, please notice the RT9059A internal initial logic level. For the RT9059A, the EN pin function pulls high level internally. So the regulator will be turned on when EN pin is floating.

Input Capacitor

Good bypassing is recommended from input to ground to improve AC performance. A 10 μ F input capacitor or greater located as close as possible to the IC is recommended.

Output Capacitor

The output capacitor must meet both requirements for minimum amount of capacitance and ESR in all LDOs applications. The RT9059A is designed specifically to work with low ESR ceramic output capacitor in space-saving and performance consideration. Using a at least 10 μ F ceramic capacitor on the RT9059A output ensures stability. The RT9059A still works well with output capacitor of other types due to the wide stable ESR range. Figure 5 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 no more than 0.5 inch from the VOUT pin of the RT9059A and returned to a clean analog ground.

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

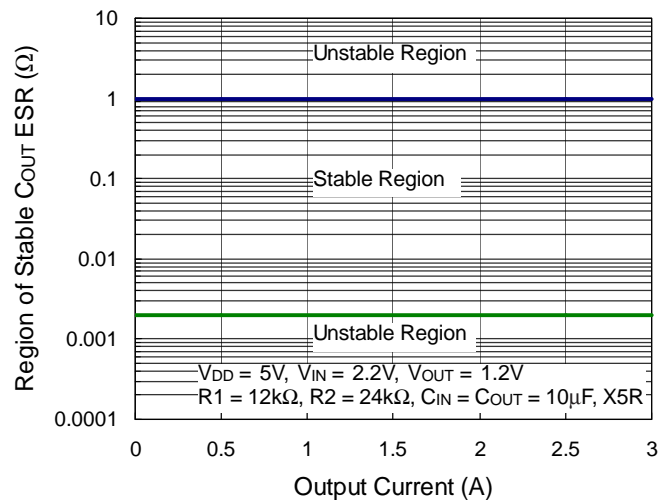


Figure 2. Region of Stable C_{OUT} ESR vs. Output Current

Current Limit

The RT9059A contains an independent current limit and the short circuit current protection to prevent unexpected applications. The current limit monitors and controls the pass transistor's gate voltage, minimum limiting the output current to 3.1A typical. When the output voltage is less than 0.2V, the short circuit current protection starts the current fold back function and maintains the loading current at maximum 1.8A. The output can be shorted to ground indefinitely without damaging the part.

Power Good

The power good function is an open-drain output. Connect a 100k Ω pull-up resistor to V_{OUT} to obtain an output voltage. The PGOOD pin will output high immediately after the output voltage arrives 90% of normal output voltage.

Thermal Shutdown Protection

Thermal protection limits power dissipation to prevent the IC from overheat. When the operation junction temperature exceeds 160°C, the over-temperature protection circuit starts the thermal shutdown function and turns the pass transistor off. The pass transistor turns on again after the junction temperature cools by 70°C.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

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

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA} , is layout dependent. For WDFN-10L 3x3 package, the thermal resistance, θ_{JA} , is 32.8°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at $T_A = 25^\circ\text{C}$ can be calculated by the following formula :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (32.8^\circ\text{C/W}) = 3.04\text{W for WDFN-10L 3x3 package}$$

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA} . The derating curve in Figure 3 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

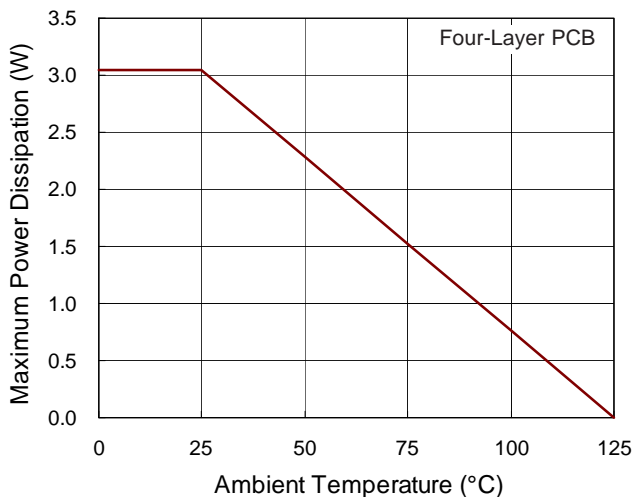
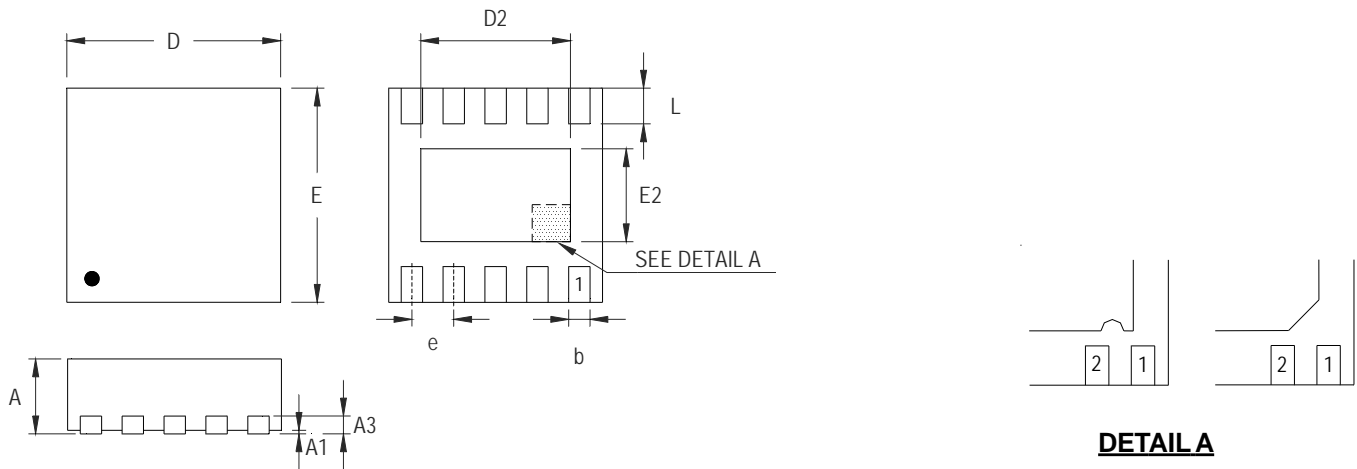


Figure 3. Derating Curve of Maximum Power Dissipation

Outline Dimension



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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