# 14V, 2μA $I_Q$, 200mA LDO Regulator

## General Description

The RTQ2511 is a low-dropout (LDO) voltage regulator with enable function offering benefits of up to 14V input voltage, low-dropout, low-power operation, and miniaturized packaging.

The features of low quiescent current as low as 2μA and zero disable current is ideal for powering the battery equipment to a longer service life. The RTQ2511 is stable with ceramic output capacitors over its wide input range from 3.5V to 14V and entire range of output load current (0mA to 200mA).

## Applications

- Portable, Battery Powered Equipments
- Ultra Low Voltage Microcontrollers
- Notebook Computers

## Marking Information

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

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

- **AEC-Q100 Grade 1 Qualified**
- **2μA Ground Current at No Load**
- **±2% Output Accuracy**
- **200mA Output Current**
- **Maximum Operating Input Voltage 14V**
- **Dropout Voltage : 0.4V at 100mA**
- **Support Fixed Output Voltage from 2.5V to 9V (0.1V per step, 3.3V and 5V are available)**
- **Current-Limit Protection**
- **Over-Temperature Protection**
- **RoHS Compliant and Halogen Free**

## Ordering Information

RTQ2511-□□□□ -QA

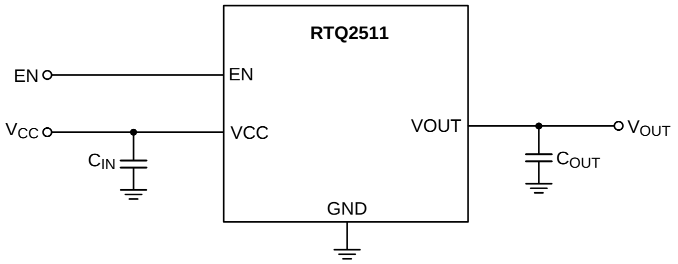
Grade
QA : AEC-Q100 Qualified and Screened by High Temperature

Package Type
QW : WDFN-8L 3x3 (W-Type)

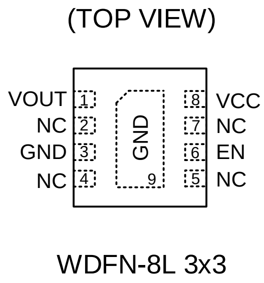
Lead Plating System
G : Green (Halogen Free and Pb Free)

Output Voltage
25 : 2.5V
28 : 2.8
30 : 3.0V
33 : 3.3V
50 : 5V
62 : 6.2V
80 : 8V
90 : 9V

## Simplified Application Circuit



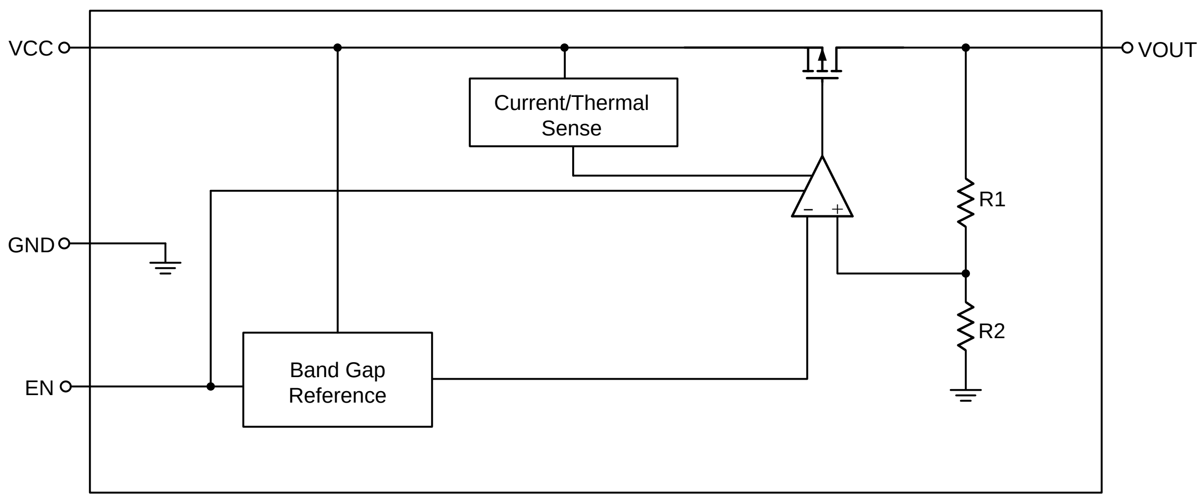
## Pin Configuration




## Functional Pin Description

| Pin No. | Pin Name | Pin Function |
|---|---|---|
| 1 | VOUT | Output of the regulator. |
| 2, 4, 5, 7 | NC | No internal connection. |
| 3, 9 (Exposed Pad) | GND | Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum thermal dissipation. |
| 6 | EN | Enable control input. |
| 8 | VCC | Supply voltage input. |

## Functional Block Diagram



# Operation

### Basic Operation

The RTQ2511 is a low quiescent current linear regulator designed especially for low external component systems. The input voltage range is from 3.5V to 14V.

The minimum required output capacitance for stable operation is 1μF effective capacitance after consideration of the temperature and voltage coefficient of the capacitor.

### Output Transistor

The RTQ2511 builds in a P-MOSFET output transistor which provides a low switch-on resistance for low dropout voltage applications.

### Error Amplifier

The Error Amplifier compares the internal reference voltage with the output feedback voltage from the internal divider, and controls the Gate voltage of P-MOSFET to support good line regulation and load regulation at output voltage.

### Enable

The RTQ2511 delivers the output power when it is set to enable state. When it works in disable state, there is no output power and the operation quiescent current is zero.

### Current-Limit Protection

The RTQ2511 provides current limit function to prevent the device from damages during over-load or shorted-circuit conditions. This current is detected by an internal sensing transistor.

### Over-Temperature Protection

The over-temperature protection function turns off the P-MOSFET when the junction temperature exceeds 150°C (typ.) and the output current exceeds 30mA. Once the junction temperature cools down by approximately 20°C, the regulator automatically resumes operation.

## Absolute Maximum Ratings (Note 1)

- VCC, EN to GND ---------- −0.3V to 15V
- VOUT to GND
  RTQ2511-90 ---------- −0.3V to 15V
  RTQ2511-25/ RTQ2511-33/RTQ2511-50 ---------- −0.3V to 6V
- VOUT to VCC ---------- −15V to 0.3V
- Power Dissipation, $P_D$ @ $T_A$ = 25°C
  WDFN-8L 3x3 ---------- 3.57W
- Package Thermal Resistance (Note 2)
  WDFN-8L 3x3, $\theta_{JA}$ ---------- 35°C/W
  WDFN-8L 3x3, $\theta_{JC}$ ---------- 9°C/W
- Lead Temperature (Soldering, 10 sec) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- −60°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Model) ---------- 2kV

## Recommended Operating Conditions (Note 4)

- Supply Input Voltage, VCC ---------- 3.5V to 14V
- Junction Temperature Range ---------- −40°C to 150°C
- Ambient Temperature Range ---------- −40°C to 125°C

## Electrical Characteristics

($V_{CC}$ = 14V, $T_J$ = −40°C to 125°C, unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | | 3.5 | -- | 14 | V |
| Output Voltage Range | $V_{OUT}$ | | 2.5 | -- | 12 | V |
| DC Output Accuracy | $\Delta V_{OUT}$ | $I_{LOAD}$ = 1mA, $V_{CC}$ = 14V | −2 | -- | 2 | % |
| Dropout Voltage | $V_{DROP}$ | $I_{LOAD}$ = 100mA, $V_{CC}$ > 4.5V | -- | 0.4 | 1.2 | V |
| | | $I_{LOAD}$ = 100mA, $V_{CC}$ > 3.5V and < 4.5V | -- | -- | 1.5 | V |
| VCC Consumption Current | $I_Q$ | $I_{LOAD}$ = 0mA, $V_{OUT}$ ≤ 5.5V | -- | 2 | 3.5 | μA |
| | | $I_{LOAD}$ = 0mA, $V_{OUT}$ > 5.5V | -- | 3.5 | 5 | μA |
| Shutdown GND Current | | $V_{EN}$ = 0V, $V_{CC}$ = 14V, $V_{OUT}$ = 0V | -- | 0.01 | 1 | μA |
| EN Input Current | $I_{EN}$ | $V_{EN}$ = 14V, $V_{CC}$ = 14V | -- | -- | 0.1 | μA |
| Line Regulation | $\Delta V_{LINE}$ | $I_{LOAD}$ = 1mA, 5.5V < $V_{CC}$ < 14V | -- | -- | 0.4 | % |
| | | $I_{LOAD}$ = 1mA, 3.5V < $V_{CC}$ < 5.5V | -- | 0.1 | 0.3 | % |

| Parameter | | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| Load Regulation | | $\Delta V_{LOAD}$ | 1mA < $I_{LOAD}$ < 100mA, –40°C ≤ $T_J$ ≤ 105°C, $V_{CC}$ = $V_{OUT}$ + 2V | -- | 0.5 | 1 | % |
| Load Regulation | | $\Delta V_{LOAD}$ | 1mA < $I_{LOAD}$ < 100mA, 105°C < $T_J$ ≤ 125°C, $V_{CC}$ = $V_{OUT}$ + 2V | -- | -- | 2 | % |
| Output Current Limit | | $I_{LIM}$ | $V_{CC}$ = $V_{OUT}$ + 2V | 210 | 350 | 490 | mA |
| Enable Input Voltage | Logic-High | $V_{IH}$ | | 1.7 | -- | -- | V |
| | Logic-Low | $V_{IL}$ | | -- | -- | 0.6 | |
| Thermal Shutdown Temperature | | $T_{SD}$ | $I_{LOAD}$ = 30mA, (Note 5) | -- | 150 | -- | °C |
| Thermal Shutdown Hysteresis | | $\Delta T_{SD}$ | (Note 5) | -- | 20 | -- | °C |

**Note 1.** Stresses beyond those listed "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.

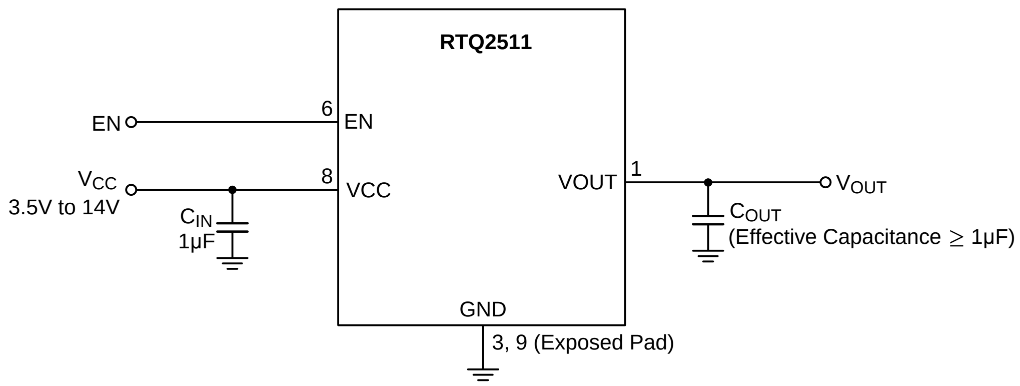
**Note 2.** $\theta_{JA}$ is measured under natural convection (still air) at $T_A$ = 25°C with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard. $\theta_{JC}$ is measured at the exposed pad of the package.

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

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

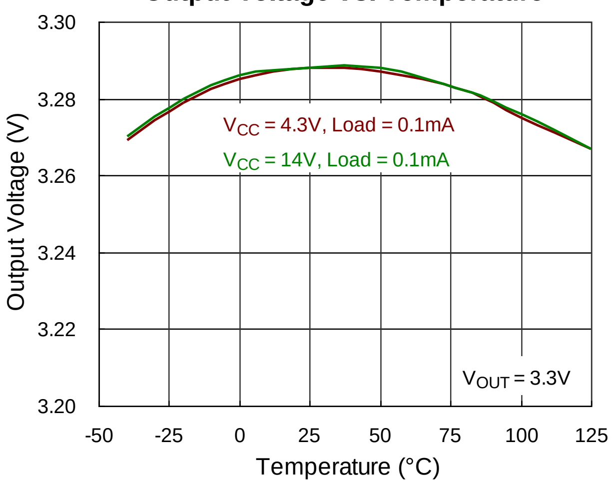
**Note 5.** Guarantee by design.

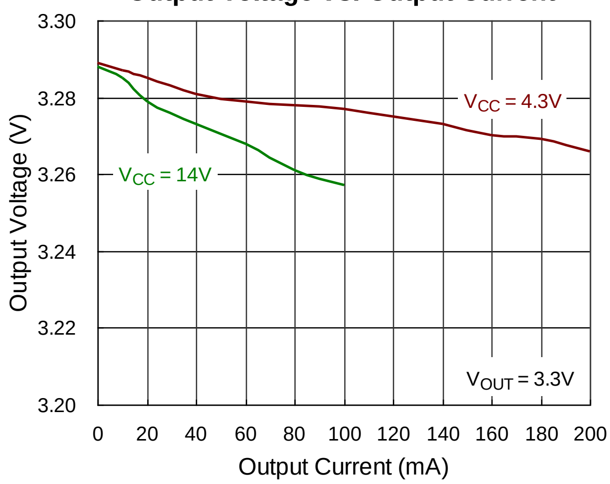
## Typical Application Circuit

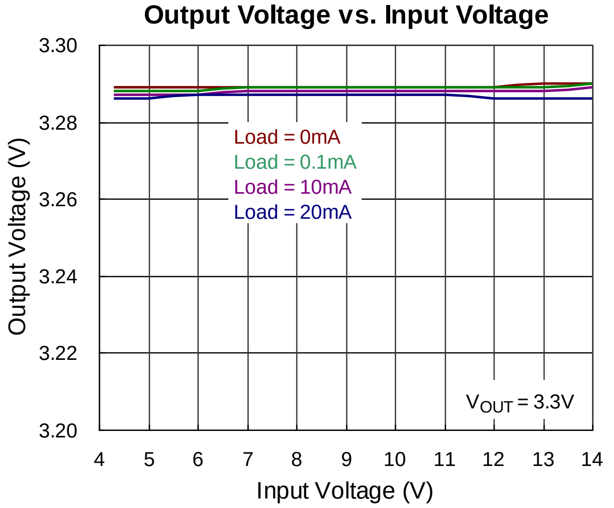


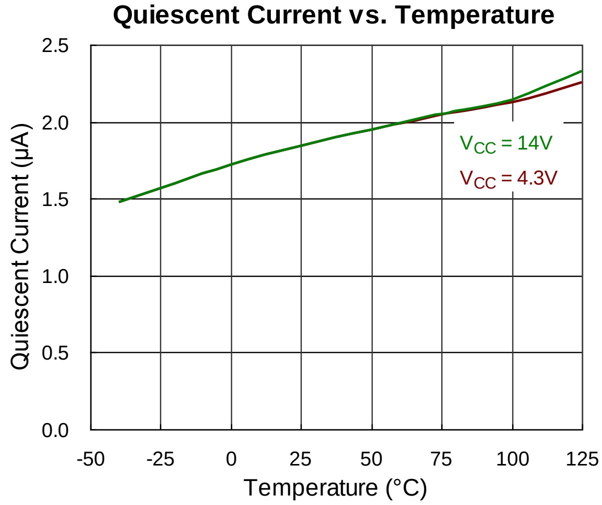

Note : All input and output capacitance in the suggested parameter mean the effective capacitance. The effective capacitance needs to consider any De-rating Effect like DC bias.

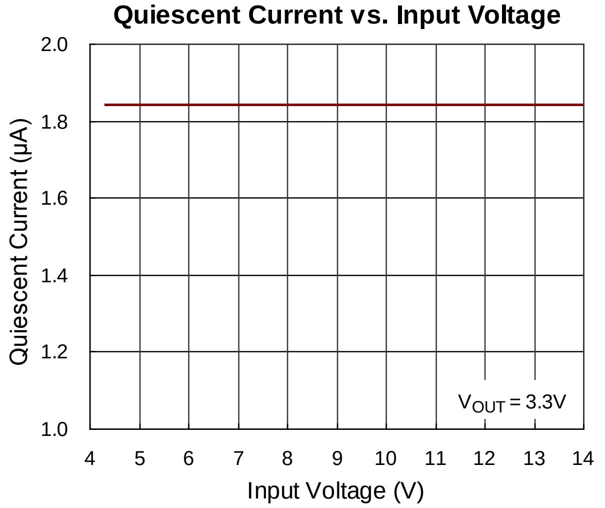
## Typical Operating Characteristics

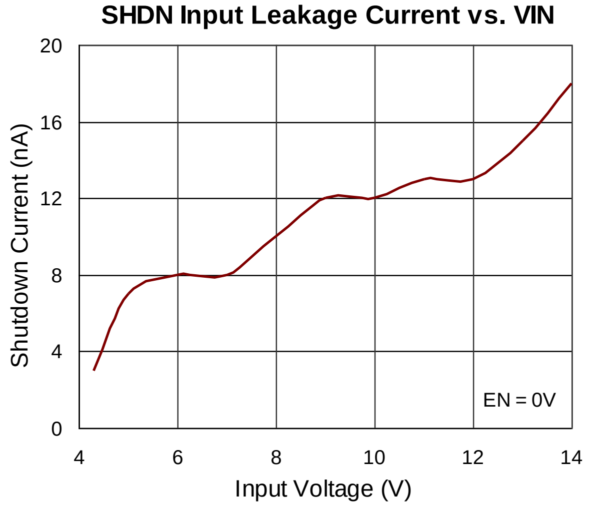


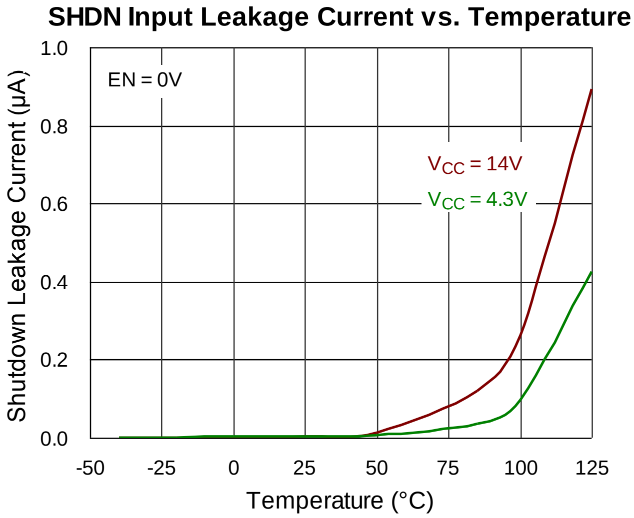



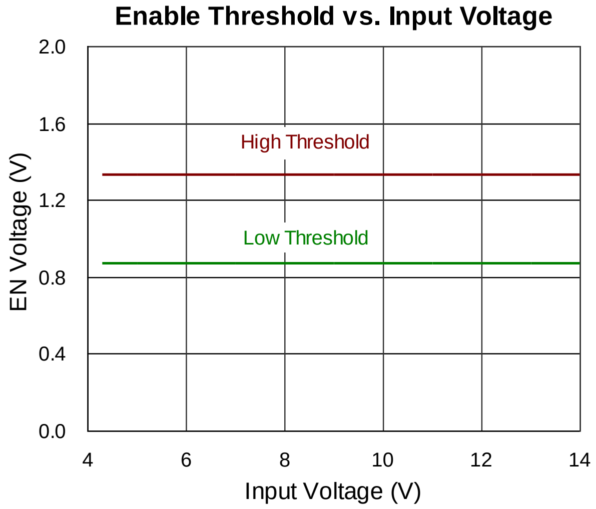



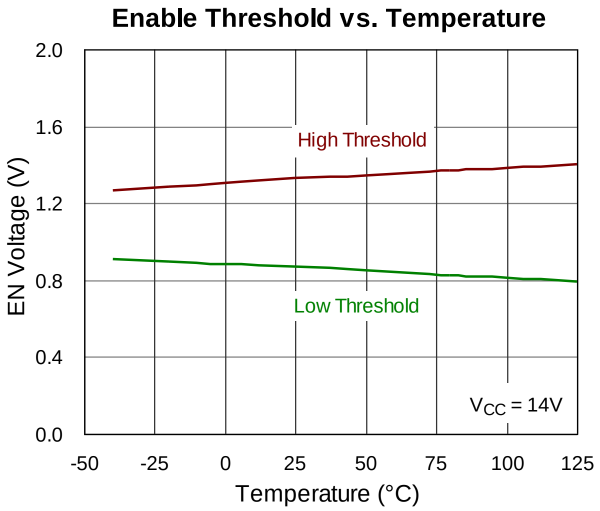



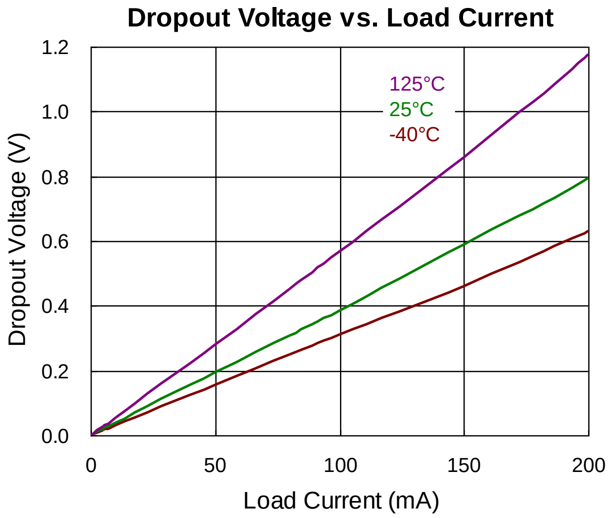



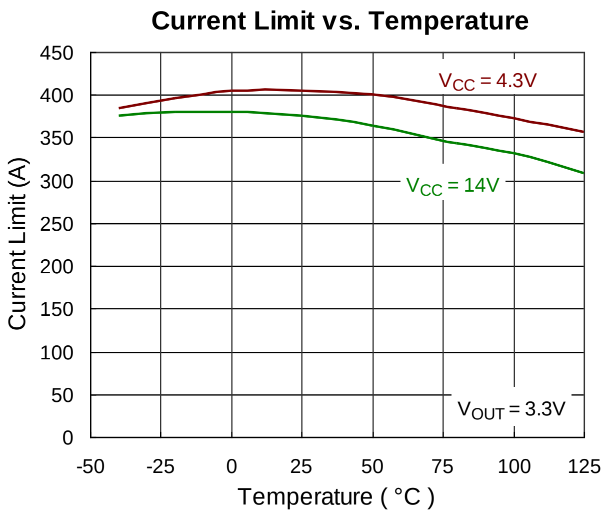



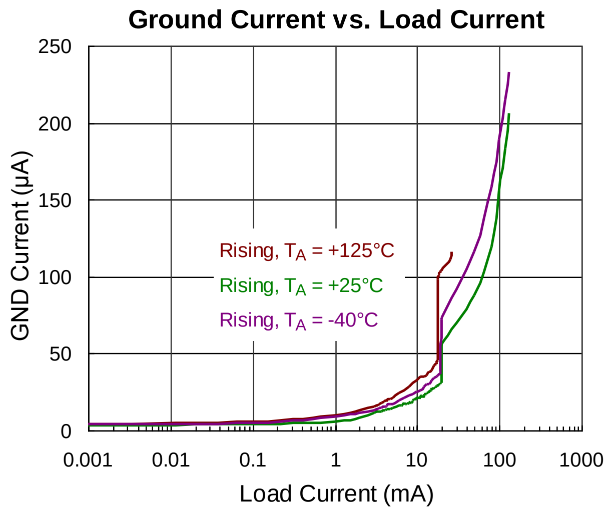

SHDN Input Leakage Current vs. Temperature
EN = 0V
VCC = 14V
VCC = 4.3V
Shutdown Leakage Current (μA)
1.0
0.8
0.6
0.4
0.2
0.0
-50
-25
0
25
50
75
100
125
Temperature (°C)


Enable Threshold vs. Input Voltage
High Threshold
Low Threshold
EN Voltage (V)
2.0
1.6
1.2
0.8
0.4
0.0
4
6
8
10
12
14
Input Voltage (V)

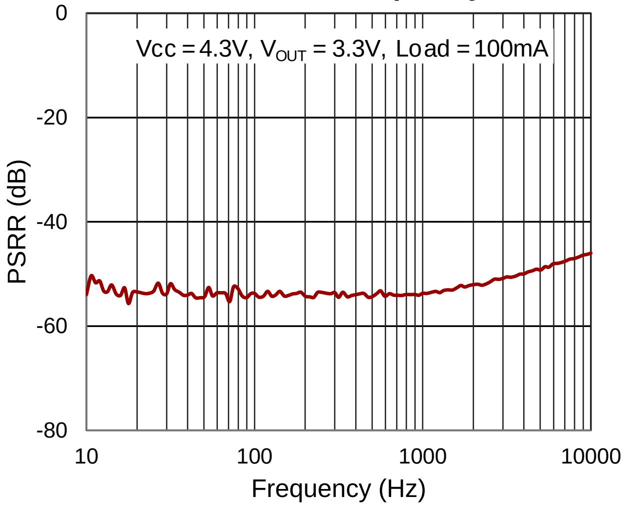

Enable Threshold vs. Temperature
High Threshold
Low Threshold
VCC = 14V
EN Voltage (V)
2.0
1.6
1.2
0.8
0.4
0.0
-50
-25
0
25
50
75
100
125
Temperature (°C)


Dropout Voltage vs. Load Current
125°C
25°C
-40°C
Dropout Voltage (V)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
Load Current (mA)

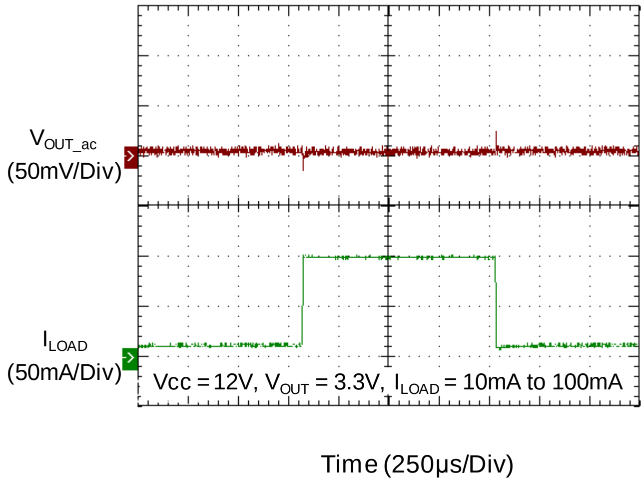

Current Limit vs. Temperature
VCC = 4.3V
VCC = 14V
VOUT = 3.3V
Current Limit (A)
450
400
350
300
250
200
150
100
50
0
-50
-25
0
25
50
75
100
125
Temperature ( °C )


Ground Current vs. Load Current
Rising, TA = +125°C
Rising, TA = +25°C
Rising, TA = -40°C
GND Current (μA)
250
200
150
100
50
0
0.001
0.01
0.1
1
10
100
1000
Load Current (mA)

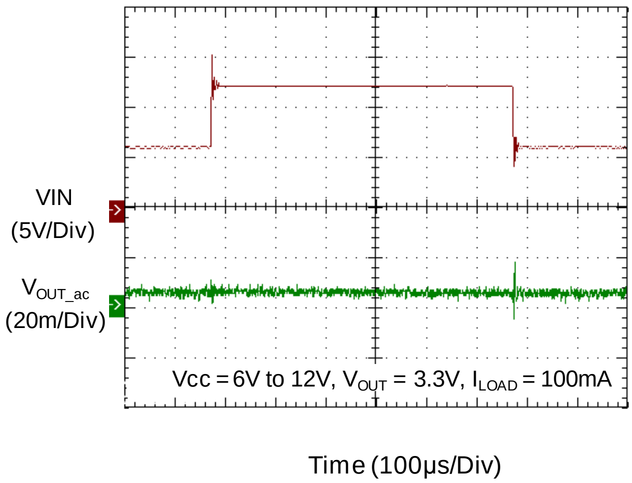
**PSRR vs. Frequency**



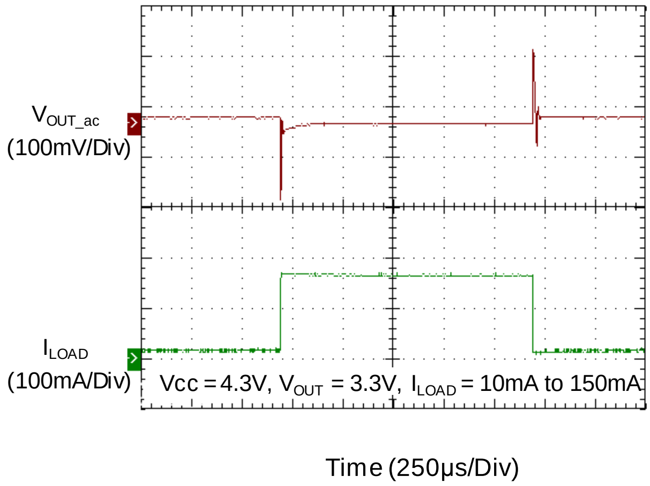

**Load Transient Response**



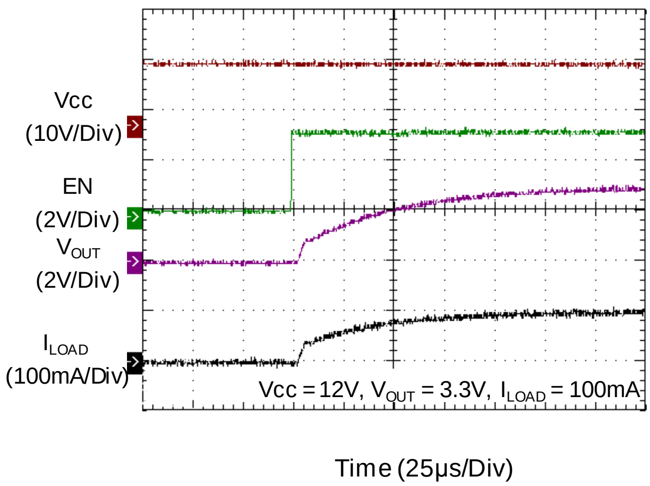

**Line Transient Response**



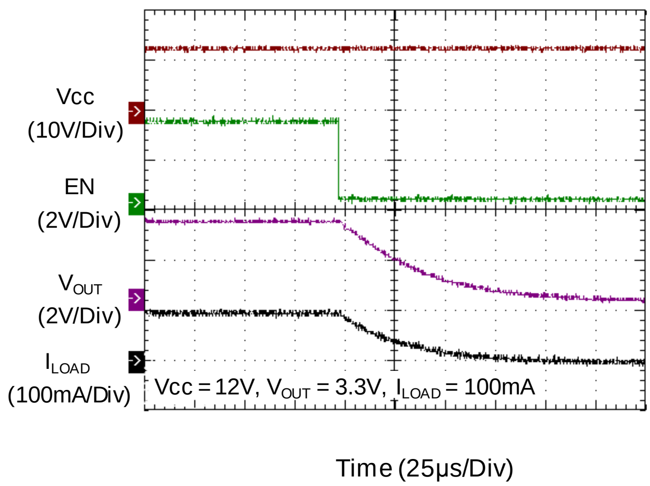

**Load Transient Response**




**Power On from EN**




**Power Off from EN**



## Application Information

Like any low dropout linear regulator, the RTQ2511's external input and output capacitors must be properly selected for stability and performance. Use a 1μF or larger input capacitor and place it close to the IC's VCC and GND pins. Any output capacitor meeting meets the minimum 1mΩ ESR (Equivalent Series Resistance) and effective capacitance larger than 1μF requirement may be used. Place the output capacitor close to the IC's VOUT and GND pins. Increasing capacitance and decreasing ESR can improve the circuit's PSRR and line transient response.

### Enable

The RTQ2511 goes into sleep mode when the EN pin is in a logic low condition. During this condition, the RTQ2511 has an EN pin to turn on or turn off the regulator, When the EN pin is in logic high, the regulator will be turned on. The shutdown current is 0μA typical. The EN pin may be directly tied to Vcc to keep the part on. The Enable input is CMOS logic and cannot be left floating.

### 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 in heavy load measuring, Δsupply will cause Δtemperature. And Δtemperature will cause Δoutput voltage. So the temperature effect is include in heavy load PSRR measuring.

### Current Limit

The RTQ2511 contains an independent current limiter, which monitors and controls the pass transistor's gate voltage, limiting the output current to 0.35A (typ.). The output can be shorted to ground indefinitely without damaging the part.

### Thermal Considerations

The junction temperature should never exceed the absolute maximum junction temperature $T_{J(MAX)}$, listed under Absolute Maximum Ratings, to avoid permanent damage to the device. The maximum allowable power dissipation depends on the thermal resistance of the IC package, the PCB layout, the rate of surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using 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 $\theta_{JA}$ is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is 150°C. The junction-to-ambient thermal resistance, $\theta_{JA}$, is highly package dependent. For a WDFN-8L 3x3 package, the thermal resistance, $\theta_{JA}$, is 35°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at $T_A$ = 25°C can be calculated as below :

$P_{D(MAX)}$ = (150°C − 25°C) / (35°C/W) = 3.57W for a WDFN-8L 3x3 package.

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, $\theta_{JA}$. The derating curve in Figure 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

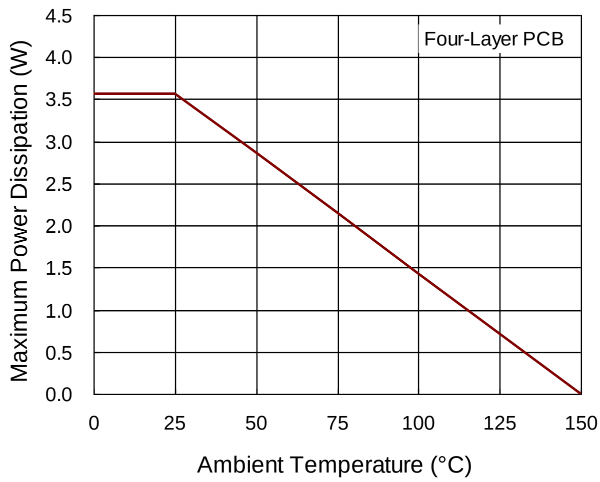
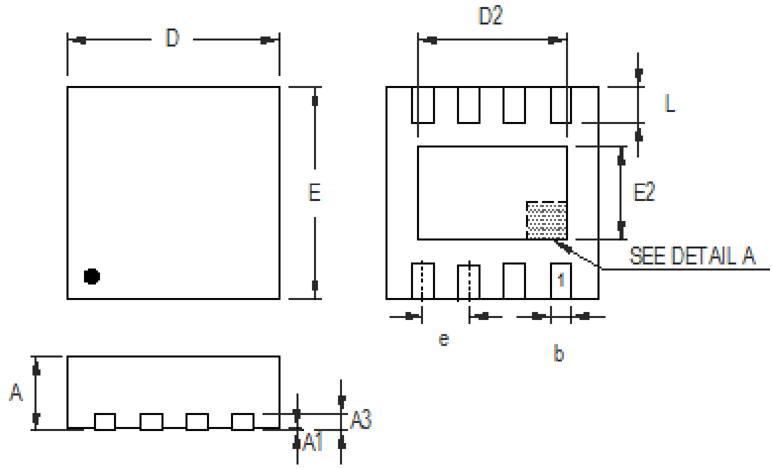
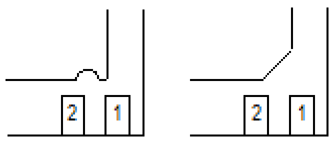



Figure 1. Derating Curve of Maximum Power Dissipation

## Outline Dimension




**DETAIL A**

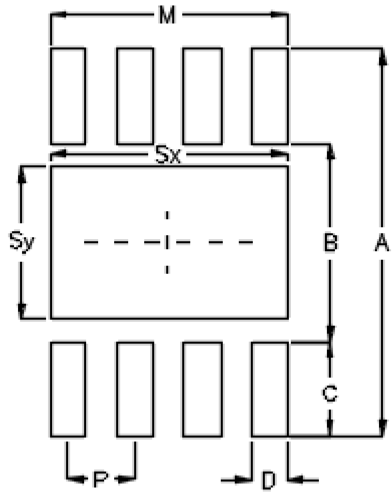
Pin #1 ID and Tie Bar Mark Options

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 | 0.200 | 0.300 | 0.008 | 0.012 |
| D | 2.950 | 3.050 | 0.116 | 0.120 |
| D2 | 2.100 | 2.350 | 0.083 | 0.093 |
| E | 2.950 | 3.050 | 0.116 | 0.120 |
| E2 | 1.350 | 1.600 | 0.053 | 0.063 |
| e | 0.650 | | 0.026 | |
| L | 0.425 | 0.525 | 0.017 | 0.021 |

**W-Type 8L DFN 3x3 Package**

## Footprint Information




| Package | Number of Pin | Footprint Dimension (mm) | | | | | | | | Tolerance |
|---|---|---|---|---|---|---|---|---|---|---|
| | | P | A | B | C | D | Sx | Sy | M | |
| V/W/U/XDFN3*3-8 | 8 | 0.65 | 3.80 | 1.94 | 0.93 | 0.35 | 2.30 | 1.50 | 2.30 | ±0.05 |

**Richtek Technology Corporation**
14F, No. 8, Tai Yuen 1st Street, Chupei City
Hsinchu, Taiwan, R.O.C.
Tel: (8863)5526789