600mA, Ultra-Low Dropout, CMOS Regulator

General Description
The RT9187C is a high-performance, 600mA LDO regulator, offering extremely high PSRR and ultra-low dropout. This chip is ideal for portable RF and wireless applications with demanding performance and space requirements.

A noise reduction pin is also available for further reduction of output noise. Regulator ground current increases only slightly in dropout, further prolonging the battery life. The RT9187C also works well with low-ESR ceramic capacitors, reducing the amount of board space necessary for power applications, critical in hand-held wireless devices.

The RT9187C consumes less than 0.1μA in shutdown mode. The other features include ultra-low dropout voltage, high output accuracy, current limiting protection, and high ripple rejection ratio. The RT9187C is available in the SOT-23-5 package.

Ordering Information
RT9187C□□
   Package Type
   B : SOT-23-5
   Lead Plating System
   G : Green (Halogen Free and Pb Free)

Features
- Ultra-Low-Noise for RF Application
- Ultra-Fast Response in Line/Load Transient
- <0.1μA Standby Current When Shutdown
- Low Dropout : 100mV at 500mA
- Wide Operating Voltage Ranges : 2.5V to 5.5V
- TTL-Logic-Controlled Shutdown Input
- Current Limiting Protection
- Thermal Shutdown Protection
- Only 2.2μF Output Capacitor Required for Stability
- High Power Supply Rejection Ratio
- RoHS Compliant and Halogen Free

Applications
- CDMA/GSM Cellular Handsets
- Battery-Powered Equipment
- Laptop, Palmtops, Notebook Computers
- Hand-Held Instruments
- Mini PCI & PCI-Express Cards
- PCMCIA & New Cards
- Portable Information Appliances

Marking Information
40=DNN : Product Code
DNN : Date Code

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.
**Typical Application Circuit**

```
VOUT = VREF \times \left(1 + \frac{R1}{R2}\right) (V)
```

Note: The value of R2 should be less than 100kΩ to maintain regulation.

**Function Pin Description**

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VIN</td>
<td>Voltage Input.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground.</td>
</tr>
<tr>
<td>3</td>
<td>EN</td>
<td>Chip Enable (Active High).</td>
</tr>
<tr>
<td>4</td>
<td>ADJ</td>
<td>Output Voltage Feedback.</td>
</tr>
<tr>
<td>5</td>
<td>VOUT</td>
<td>Voltage Output.</td>
</tr>
</tbody>
</table>

**Function Block Diagram**

```
\text{EN} \quad \text{OTP} \\
\text{POR} \quad \text{BIAS} \\
\text{VOUT} \quad \text{R1} \\
\text{R2} \quad \text{Current Limit} \\
\text{Quick start} \\
\text{VREF} \quad \text{ADJ} \\
\text{VIN} \quad \text{GND}
```
Absolute Maximum Ratings  (Note 1)

- Supply Input Voltage........................................................................................................ 6V
- EN Input Voltage.................................................................................................................. 6V
- Power Dissipation, \( P_D @ T_A = 25^\circ C \)
  SOT-23-5 .................................................................................................................. 0.400W
- Package Thermal Resistance (Note 2)
  SOT-23-5, \( \theta_{JA} \) ..................................................................................... 250\(^\circ\)C/W
- Lead Temperature (Soldering, 10 sec.) ............................................................................. 260\(^\circ\)C
- Junction Temperature ..................................................................................................... 150\(^\circ\)C
- Storage Temperature Range ......................................................................................... \(-65^\circ C \) to \(150^\circ C\)
- ESD Susceptibility (Note 3)
  HBM (Human Body Model).......................................................................................... 2kV

Recommended Operating Conditions  (Note 4)

- Supply Input Voltage........................................................................................................ 2.5V to 5.5V
- EN Input Voltage............................................................................................................. 0V to 5.5V
- Junction Temperature Range ......................................................................................... \(-40^\circ C \) to \(125^\circ C\)
- Ambient Temperature Range......................................................................................... \(-40^\circ C \) to \(85^\circ C\)

Electrical Characteristics

\((V_{IN} = V_{OUT} + 1V, V_{EN} = V_{IN}, C_{IN} = C_{OUT} = 2.2\mu F \) (Ceramic), \(T_A = 25^\circ C\), unless otherwise specified\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Voltage Tolerance</td>
<td>( V_{REF} )</td>
<td>( V_{ADJ} = V_{REF} )</td>
<td>0.784</td>
<td>0.8</td>
<td>0.816</td>
<td>V</td>
</tr>
<tr>
<td>ADJ Pin Current</td>
<td>( I_{ADJ} )</td>
<td>( V_{ADJ} = V_{REF} )</td>
<td>--</td>
<td>10</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>Quiescent Current (Note 5)</td>
<td>( I_Q )</td>
<td>( V_{EN} \geq V_{IH}, I_{OUT} = 0mA )</td>
<td>--</td>
<td>300</td>
<td>400</td>
<td>( \mu A )</td>
</tr>
<tr>
<td>Standby Current (Note 6)</td>
<td>( I_{STBY} )</td>
<td>( V_{EN} \leq V_{IL}, V_{IN} = 3.3V )</td>
<td>--</td>
<td>0.1</td>
<td>1</td>
<td>( \mu A )</td>
</tr>
<tr>
<td>Current Limit (Note 5)</td>
<td>( I_{LIM} )</td>
<td>( R_{LOAD} = 0.5\Omega, V_{IN} = 3.3V )</td>
<td>0.9</td>
<td>--</td>
<td>--</td>
<td>A</td>
</tr>
<tr>
<td>Dropout Voltage (Note 7)</td>
<td>( V_{DROP} )</td>
<td>( I_{OUT} = 0.3A, V_{OUT} = 5V )</td>
<td>--</td>
<td>60</td>
<td>100</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( I_{OUT} = 0.5A, V_{OUT} = 5V )</td>
<td>--</td>
<td>100</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Load Regulation (Note 8)</td>
<td>( \Delta V_{LOAD} )</td>
<td>( V_{IN} = (V_{OUT} + 0.5V) ) (10mA &lt; I_{OUT} &lt; 0.5A)</td>
<td>--</td>
<td>0.4</td>
<td>--</td>
<td>( %/A )</td>
</tr>
<tr>
<td>EN Threshold Voltage</td>
<td>Logic-High</td>
<td>( V_{IH} )</td>
<td>( V_{IN} = 3.3V )</td>
<td>1.8</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Logic-Low</td>
<td>( V_{IL} )</td>
<td>( V_{IN} = 3.3V )</td>
<td>--</td>
<td>--</td>
<td>0.6</td>
</tr>
<tr>
<td>EN Current</td>
<td>( I_{EN} )</td>
<td>( V_{IN} = 3.3V, ) Enable</td>
<td>--</td>
<td>0.1</td>
<td>1</td>
<td>( \mu A )</td>
</tr>
<tr>
<td>Power Supply Rejection Rate</td>
<td>( f = 100Hz )</td>
<td>( PSRR )</td>
<td>( I_{OUT} = 300mA )</td>
<td>--</td>
<td>--</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>( f = 10kHz )</td>
<td>( PSRR )</td>
<td>--</td>
<td>--</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Line Regulation</td>
<td>( \Delta V_{LINE} )</td>
<td>( V_{IN} = (V_{OUT} + 0.5) ) (5.5V, I_{OUT} = 1mA )</td>
<td>--</td>
<td>--</td>
<td>0.3</td>
<td>%</td>
</tr>
<tr>
<td>Start-Up Time</td>
<td>( t_{Start-Up} )</td>
<td>( R_{LOAD} = 3\Omega )</td>
<td>--</td>
<td>150</td>
<td>--</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Thermal Shutdown Temperature</td>
<td>( T_{SD} )</td>
<td>--</td>
<td>170</td>
<td>--</td>
<td>( ^\circ C )</td>
<td></td>
</tr>
<tr>
<td>Thermal Shutdown Hysteresis</td>
<td>( \Delta T_{SD} )</td>
<td>--</td>
<td>30</td>
<td>--</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 at \( T_A = 25°C \) on a low effective thermal conductivity single-layer test board per JEDEC 51-3.

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. Quiescent, or ground current, is the difference between input and output currents. It is defined by \( I_Q = I_IN - I_OUT \) under no load condition (\( I_OUT = 0mA \)). The total current drawn from the supply is the sum of the load current plus the ground pin current.

Note 6. Standby current is the input current drawn by a regulator when the output voltage is disabled by a shutdown signal (\( V_{EN} < 0.6V \)).

Note 7. The dropout voltage is defined as \( V_{IN} - V_{OUT} \), which is measured when \( V_{OUT} = V_{OUT(NORMAL)} - 100mV \).

Note 8. Regulation is measured at constant junction temperature by using a 2ms current pulse. Devices are tested for load regulation in the load range from 10mA to 0.5A.
Typical Operating Characteristics

\( (C_{OUT} = 2.2 \mu F \times 5R, \text{unless otherwise specified}) \)

**Dropout Voltage vs. Load Current**

- \( V_{OUT} = 2.8V \)
- \( T_J = 25^\circ C \)
- \( T_J = 125^\circ C \)
- \( T_J = -40^\circ C \)

**Reference Voltage vs. Temperature**

- Reference Voltage (V)
- Temperature (°C)
- \( V_{IN} = 3.3V \)

**Quiescent Current vs. Temperature**

- Quiescent Current (\( \mu A \))
- Temperature (°C)
- \( V_{IN} = 3.3V \)

**EN Threshold Voltage vs. Temperature**

- Threshold Voltage (V)
- Temperature (°C)
- Rising
- Falling

**EN Pin Shutdown Response**

- \( V_{EN} \) (2V/Div)
- \( V_{OUT} \) (2V/Div)
- Time (500µs/Div)
- \( V_{IN} = 3.3V, V_{OUT} = 2.8V, I_{OUT} = 560mA \)
Line Transient Response

Vin = 3.3V to 4.3V, Iload : 300mA

Time (500μs/Div)

PSRR

Vin = VEN = 3.3V ± 50mV

Iload = 100mA

Iload = 56mA

VOUT = 3.3V ± 50mV

Region of Stable COUT ESR vs. Load Current

Vin = 3.3V

Unstable Range

Stable Range

Region of Stable COUT ESR (Ω)

Load Current (A)

0

0.001

0.01

0.1

1

10

100

Frequency (kHz)

PSRR (dB)
Applications Information

Output Voltage Setting
The voltage divider resistors can have values up to 100kΩ because of the very high impedance and low bias current of the sense comparator. The output voltage is set according to the following equation:

\[ V_{\text{OUT}} = V_{\text{REF}} \times \left(1 + \frac{R_1}{R_2}\right) \]

where \( V_{\text{REF}} \) is the reference voltage with a typical value of 0.8V. When the ADJ short to VOUT, there must be a resistor (<100kΩ) from ADJ to GND.

Chip Enable Operation
The RT9187C goes into sleep mode when the EN pin is in a logic low condition. In this condition, the pass transistor, error amplifier, and band gap are all turned off, reducing the supply current to 1μA (max.). The EN pin can be directly tied to VIN to keep the part on.

\( C_{\text{IN}} \) and \( C_{\text{OUT}} \) Selection
Like any low dropout regulator, the external capacitors of the RT9187C must be carefully selected for regulator stability and performance. Using a capacitor of at least 2.2μF is suitable. The input capacitor must be located at a distance of not more than 0.5 inch from the input pin of the IC. Any good quality ceramic capacitor can be used. However, a capacitor with larger value and lower ESR (Equivalent Series Resistance) is recommended since it will provide better PSRR and line transient response. The RT9187C is designed specifically to work with low ESR ceramic output capacitor for space saving and performance consideration. Using a ceramic capacitor with value at least 2.2μF and ESR larger than 10mΩ on the RT9187C output ensures stability. Nevertheless, the RT9187C can still work well with other types of output capacitors due to its wide range of stable ESR. "Typical Operating Characteristics" shows the allowable ESR range as a function of load current for various output capacitance. Output capacitors with larger capacitance can reduce noise and improve load transient response, stability, and PSRR. The output capacitor should be located at a distance of not more than 0.5 inch from the output pin of the RT9187C.

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:

\[ P_{\text{D(MAX)}} = \frac{(T_{\text{J(MAX)}} - T_{\text{A}})}{\theta_{\text{JA}}} \]

where \( T_{\text{J(MAX)}} \) is the maximum junction temperature, \( T_{\text{A}} \) is the ambient temperature, and \( \theta_{\text{JA}} \) 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, \( \theta_{\text{JA}} \), is layout dependent. For SOT-23-5 packages, the thermal resistance, \( \theta_{\text{JA}} \), is 250°C/W on a standard JEDEC 51-3 single-layer thermal test board. The maximum power dissipation at \( T_{\text{A}} = 25 \)°C can be calculated by the following formula:

\[ P_{\text{D(MAX)}} = \frac{(125\,^\circ\text{C} - 25\,^\circ\text{C})}{(250\,^\circ\text{C/W})} = 0.400\text{W for SOT-23-5 package} \]

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

![Derating Curve of Maximum Power Dissipation](image-url)
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SOT-23-5 Surface Mount Package

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Dimensions In Millimeters</th>
<th>Dimensions In Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.889 to 1.295</td>
<td>0.035 to 0.051</td>
</tr>
<tr>
<td>A1</td>
<td>0.000 to 0.152</td>
<td>0.000 to 0.006</td>
</tr>
<tr>
<td>B</td>
<td>1.397 to 1.803</td>
<td>0.055 to 0.071</td>
</tr>
<tr>
<td>b</td>
<td>0.356 to 0.559</td>
<td>0.014 to 0.022</td>
</tr>
<tr>
<td>C</td>
<td>2.591 to 2.997</td>
<td>0.102 to 0.118</td>
</tr>
<tr>
<td>D</td>
<td>2.692 to 3.099</td>
<td>0.106 to 0.122</td>
</tr>
<tr>
<td>e</td>
<td>0.838 to 1.041</td>
<td>0.033 to 0.041</td>
</tr>
<tr>
<td>H</td>
<td>0.080 to 0.254</td>
<td>0.003 to 0.010</td>
</tr>
<tr>
<td>L</td>
<td>0.300 to 0.610</td>
<td>0.012 to 0.024</td>
</tr>
</tbody>
</table>