

80V, Low Dropout Voltage Linear Regulator

General Description

The RT9072A/B is a high voltage (80V operation), low quiescent current, low dropout linear regulator. The device supplies 20mA output current with a maximum dropout voltage of 230mV. Its low quiescent and shutdown currents (23µA operating and 3µA shutdown) are ideal for use in battery-powered and/or high voltage systems. Ground current is well-controlled in all conditions, including dropout.

The RT9072A/B operates with any reasonable output capacitors including 1µF low-ESR ceramic types. It features excellent line and load transient responses. Internal protection circuitry includes reverse-battery protection, current limiting, thermal shutdown, and reverse current protection. Output voltage accuracy is ±3% over the entire line, load, and temperature range.

The RT9072A/B has an adjustable output voltage (1.25V to 60V). It is available in the SOT-23-5 package.

Applications

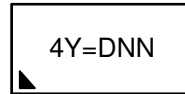
- Low Current, High Voltage Regulators
- Battery Powered Applications
- Telecom and Datacom Applications
- Automotive Applications

Features

- **Wide Input Voltage Range: 4.5V to 80V**
- **Low Quiescent Current : 23µA Operating and 3µA Shutdown**
- **Low Dropout Voltage : 180mV (typical) at 20mA**
- **Adjustable (1.25V to 60V) Output Voltage**
- **±2% Initial Output Tolerance**
- **±3% Output Tolerance over Line, Load, Temperature Range**
- **Stable with 1µF Output Capacitor**
- **Stable with Aluminum, Tantalum or Ceramic Capacitors**
- **No Reverse-Current Protection Diode Needed**
- **-80V Reverse-Battery Protection**
- **Internal Current Limit**
- **Internal Thermal Shutdown Protection**

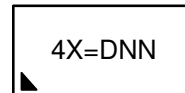
Marking Information

RT9072AGB



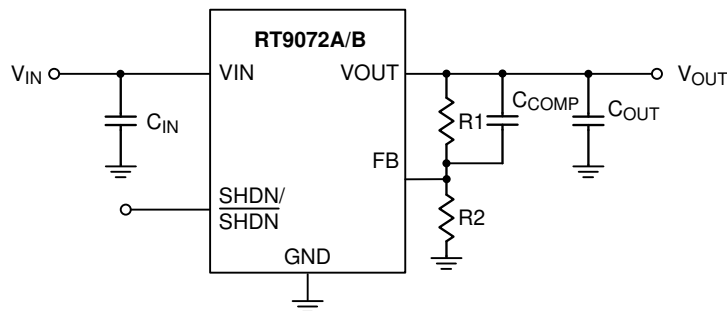
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DNN : Date Code

RT9072BGB

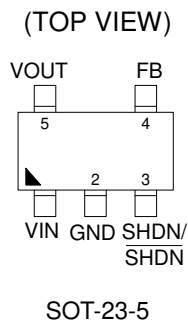


4X= : Product Code
DNN : Date Code

Simplified Application Circuit



Pin Configuration



Ordering Information

| Part No | Status | Function | Package Type | Lead Plating System |
|-----------|----------|---------------|--------------|----------------------------------|
| RT9072AGB | Obsolete | Low Shutdown | SOT-23-5 | Green (Halogen Free and Pb Free) |
| RT9072BGB | Active | High Shutdown | SOT-23-5 | Green (Halogen Free and Pb Free) |

The part status values are defined as follows :

Active : Device is in production and is recommended for new designs.

Lifebuy : The device will be discontinued, and a lifetime-buy period is in effect.

NRND : Not recommended for new designs.

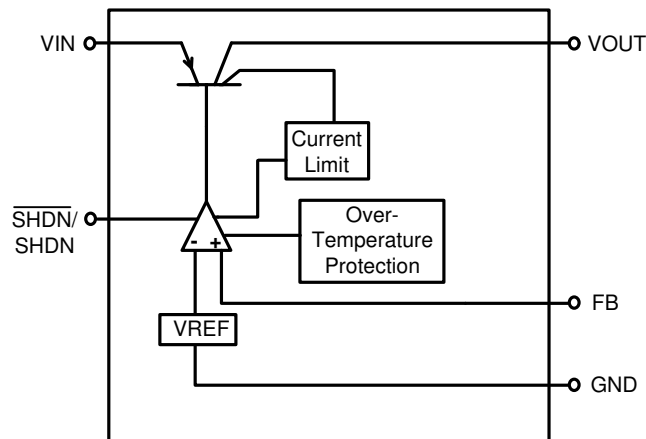
Preview : Device has been announced but is not in production.

Obsolete : Richtek has discontinued the production of the device.

Functional Pin Description

| Pin No. | Pin Name | Pin Function |
|---------|------------------------------------|---|
| 1 | VIN | Power Input. Bypass VIN with a 0.18 μ F or larger capacitor with adequate voltage rating. |
| 2 | GND | Ground. |
| 3 | SHDN (RT9072B) | Shutdown Control Input. Connect SHDN of RT9072B high to disable the output voltage and reduce the IC's quiescent current to 3 μ A (typical). Connect SHDN low to enable the output. SHDN is a high-voltage pin and can be connected directly to a high-voltage input less than 60V. |
| | $\overline{\text{SHDN}}$ (RT9072A) | Shutdown Control Input. Connect $\overline{\text{SHDN}}$ of RT9072A low to disable the output voltage and reduce the IC's quiescent current to 3 μ A (typical). Connect $\overline{\text{SHDN}}$ high to enable the output. $\overline{\text{SHDN}}$ is a high-voltage pin and can be connected directly to a high-voltage input less than 60V. |
| 4 | FB | Feedback Voltage Input. Connect to the center tap of a resistor divider for setting the output voltage. |
| 5 | VOUT | Output Voltage Pin. The VOUT pin supplies power to the load. A minimum output capacitor of 1 μ F is required for stable operation. |

Function Block Diagram



Operation

The RT9072A/B is a high input-voltage linear regulator specifically designed to minimize external components. The input voltage range is from 4.5V to 80V. The device supplies 20mA of output current with a maximum dropout voltage of 230mV. Its 23µA quiescent and 3µA shutdown currents make it ideal for use in battery-powered applications. Unlike many PNP LDO regulators, ground current does not increase much in dropout conditions.

Output Transistor

The RT9072A/B includes a built-in PNP output transistor configured for low dropout voltage. The output transistor blocks reverse current from output to input node if the output voltage is held higher than the input voltage (such as in battery-backup applications).

Error Amplifier

The Error Amplifier compares the output feedback voltage at FB to an internal reference voltage and controls the PNP output transistor's base current to maintain output voltage regulation.

Current Limit Protection

The RT9072A/B provides a current limit function to prevent damage during output over-load or shorted-circuit conditions. The output current is detected by an internal current-sense transistor.

Over-Temperature Protection

The over-temperature protection function will turn off the PNP output transistor when the internal junction temperature exceeds 150°C (typ.). Once the junction temperature cools down by approximately 20°C, the regulator will automatically resume operation.

Reverse-Battery Protection

The RT9072A/B VIN can withstand reverse voltages as high as -80V. Both the IC and the load are protected and no negative voltage will appear at the output.

Reverse-Output Protection

The RT9072A/B protects against current flow to the input (VIN) when the output voltage exceeds VIN.

If the input is left open circuit or grounded, the FB pin will act like a resistor (typically 10k) in series with a diode when pulled above ground. If the FB pin is connected to a resistor divider now and the output voltage is held higher than the input voltage, a current will conduct from output via the resistor divider and FB node to ground. Because the current is limited by the resistor divider and FB internal resistor, no additional output blocking diode is needed if the limited current is acceptable.

Shutdown Control

The RT9072B SHDN input is an active-high input that turns off the output transistor and reduces the quiescent current to 3 μ A typical. Connect SHDN to a voltage below 0.4V for normal operation.

The RT9072A $\overline{\text{SHDN}}$ input is an active-low input that turns off the output transistor and reduces the quiescent current to 3 μ A typical. Connect $\overline{\text{SHDN}}$ to a voltage above 2V for normal operation.

Absolute Maximum Ratings (Note 1)

- VIN Pin Voltage ----- -80V to 90V
- SHDN/ $\overline{\text{SHDN}}$ Pin Voltage ----- -0.3V to 60V
- VOUT to GND Voltage ----- -80V to 80V
- VOUT to VIN Voltage ----- -80V to 80V
- FB Pin Voltage ----- -0.3V to 7V
- Power Dissipation, P_D @ $T_A = 25^\circ\text{C}$
SOT-23-5 ----- 0.45W
- Package Thermal Resistance (Note 2)
SOT-23-5, θ_{JA} ----- 218.1 $^\circ\text{C}/\text{W}$
- Lead Temperature (Soldering, 10 sec.) ----- 260 $^\circ\text{C}$
- Junction Temperature ----- 150 $^\circ\text{C}$
- Storage Temperature Range ----- -65 $^\circ\text{C}$ to 150 $^\circ\text{C}$
- ESD Susceptibility (Note 3)
HBM (Human Body Model) ----- 2kV
MM (Machine Model) ----- 200V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage ----- 4.5V to 80V
- Ambient Temperature Range ----- -40 $^\circ\text{C}$ to 85 $^\circ\text{C}$
- Junction Temperature Range ----- -40 $^\circ\text{C}$ to 125 $^\circ\text{C}$

Electrical Characteristics

(4.5V < V_{IN} < 80V, $V_{\overline{\text{SHDN}}} = 2\text{V}$ (RT9072A), $V_{\overline{\text{SHDN}}} = 0\text{V}$ (RT9072B), FB pin connected to VOUT pin, $C_{OUT} = 1\mu\text{F}$ (ceramic), $T_A = 25^\circ\text{C}$, unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|----------------------|-------------------|--|------|------|------|---------------------|
| Input Voltage | V_{IN} | $I_{LOAD} = 20\text{mA}$ | 4.5 | -- | 80 | V |
| FB Pin Voltage | V_{FB} | $V_{IN} = 12\text{V}$, $I_{LOAD} = 100\mu\text{A}$ | 1.23 | 1.25 | 1.27 | V |
| | | $100\mu\text{A} < I_{LOAD} < 20\text{mA}$ | 1.21 | 1.25 | 1.29 | |
| Line Regulation | ΔV_{LINE} | $\Delta V_{IN} = 4.5\text{V}$ to 80V, $I_{LOAD} = 100\mu\text{A}$ | -- | 1 | 10 | mV |
| Load Regulation | ΔV_{LOAD} | $V_{IN} = 12\text{V}$, $\Delta I_{LOAD} = 100\mu\text{A}$ to 20mA | -- | 3 | 25 | mV |
| Dropout Voltage | V_{DROP} | $I_{LOAD} = 100\mu\text{A}$ | -- | 9 | 50 | mV |
| | | $I_{LOAD} = 1\text{mA}$ | -- | 37 | 100 | |
| | | $I_{LOAD} = 10\text{mA}$ | -- | 130 | 200 | |
| | | $I_{LOAD} = 20\text{mA}$ | -- | 180 | 230 | |
| GND Pin Current | I_{GND} | $I_{LOAD} = 0\text{mA}$ | -- | 20 | 30 | μA |
| | | $I_{LOAD} = 20\text{mA}$ | -- | 750 | 1200 | |
| Output Voltage Noise | V_{ON} | $C_{OUT} = 1\mu\text{F}$, $I_{LOAD} = 20\text{mA}$, $BW = 10\text{Hz}$ to 100kHz | -- | 120 | -- | μV_{RMS} |
| FB Pin Bias Current | I_{FB} | | -- | 8 | 100 | nA |

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|--|----------------------------|--|-----|-----|-----|--------------------|
| Shutdown Threshold | V _{IH} | RT9072A Off to On; RT9072B On to Off | -- | -- | 2 | V |
| | V _{IL} | RT9072A On to Off; RT9072B Off to On | 0.4 | -- | -- | |
| SHDN/ $\overline{\text{SHDN}}$ Pin Current | I _{SHDN} | V _{SHDN} /V $\overline{\text{SHDN}}$ = 0V | -- | 0 | 0.1 | μA |
| | I $\overline{\text{SHDN}}$ | V _{SHDN} /V $\overline{\text{SHDN}}$ = 2V | -- | 0.4 | 2 | |
| Quiescent Current in Shutdown | I _{SD} | V _{IN} = 6V, V $\overline{\text{SHDN}}$ = 2V or V _{SHDN} = 0V | -- | 3 | 10 | μA |
| Power Supply Rejection Rate | PSRR | V _{IN} = 7V (Avg), V _{RIPPLE} = 0.5 V _{P-P} , f _{RIPPLE} = 120Hz, I _{LOAD} = 20mA | -- | 75 | -- | dB |
| Output Current Limit | I _{LIM} | V _{IN} = 12V, V _{OUT} = 11V, V _{FB} = 1.2V | 25 | 40 | -- | mA |
| Input Reverse Leakage Current | I _{VINr} | V _{IN} = -80V, V _{OUT} = 0V | -- | -- | 6 | mA |
| Reverse Output Current | I _{VOUTr} | FB connect to OUT, V _{OUT} = 1.27V, V _{IN} < 0V | -- | 19 | 40 | μA |
| Over-Temperature Protection | T _{SD} | | -- | 150 | -- | $^{\circ}\text{C}$ |

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. θ_{JA} is measured at T_A = 25 $^{\circ}\text{C}$ 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

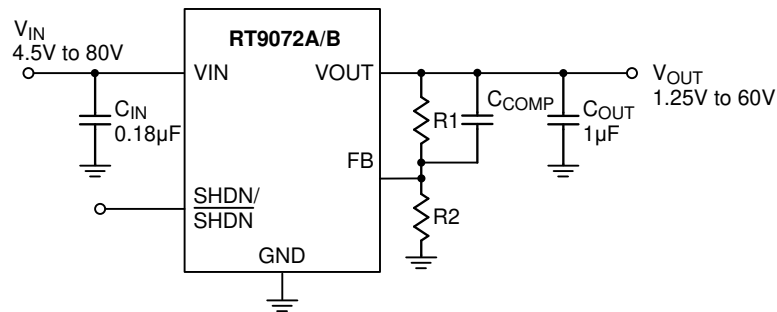


Figure 1. RT9072A/B Adjustable Output

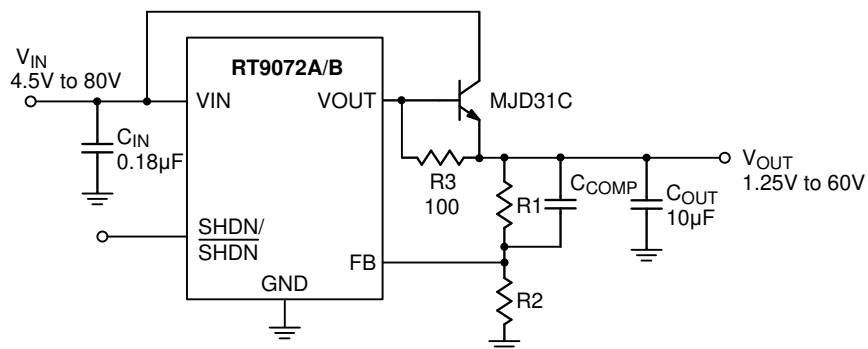
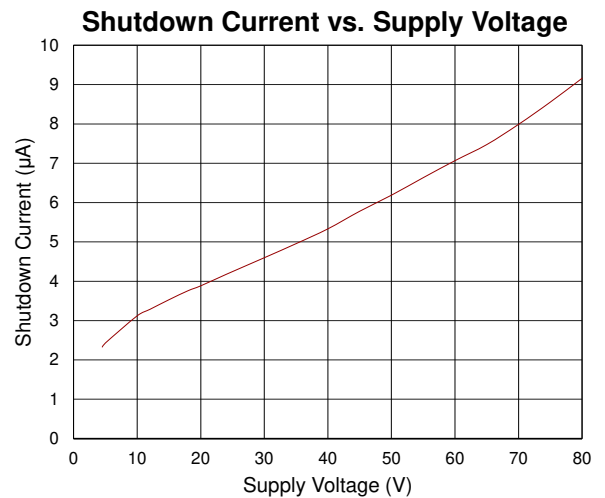
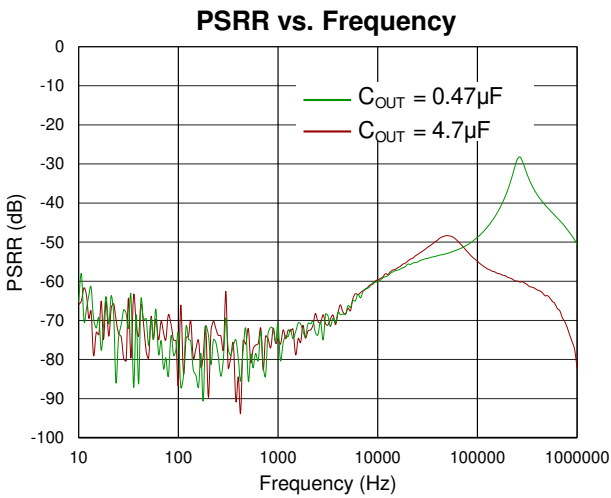
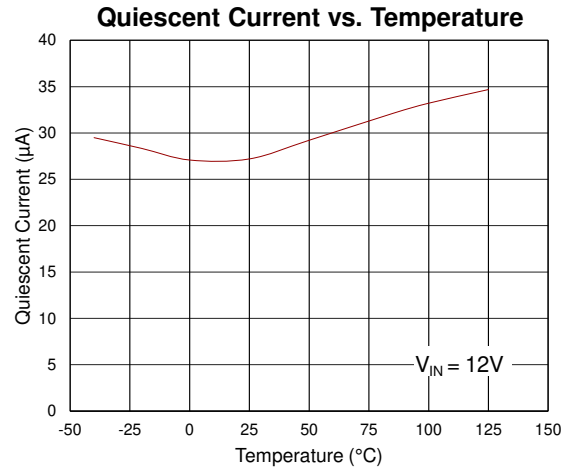
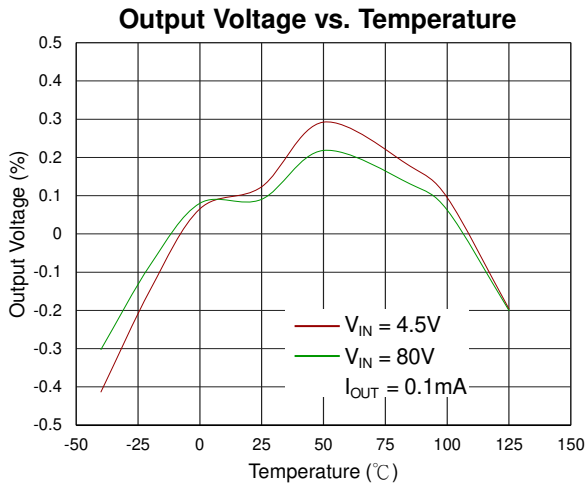
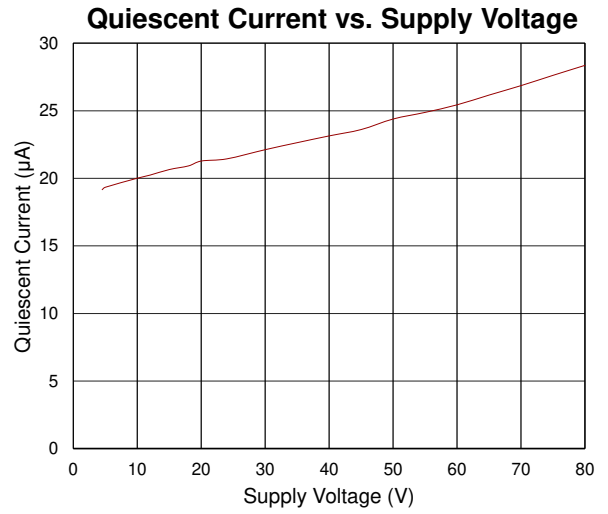
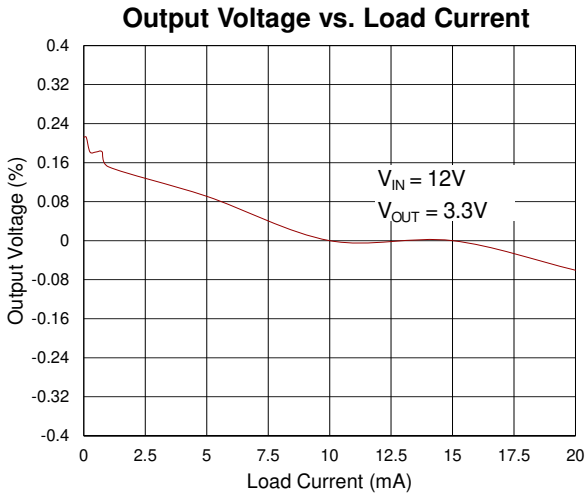
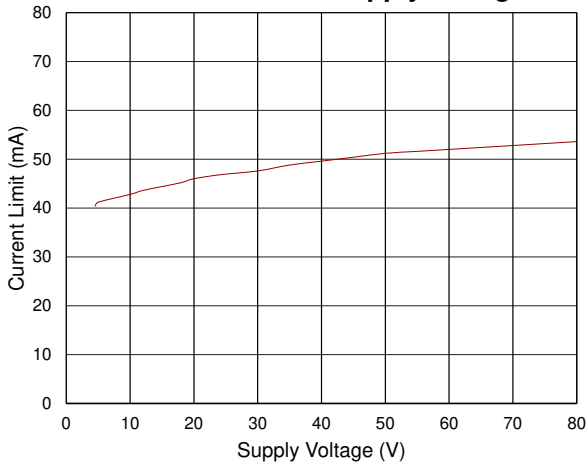


Figure 2. RT9072A/B External Transistor Application

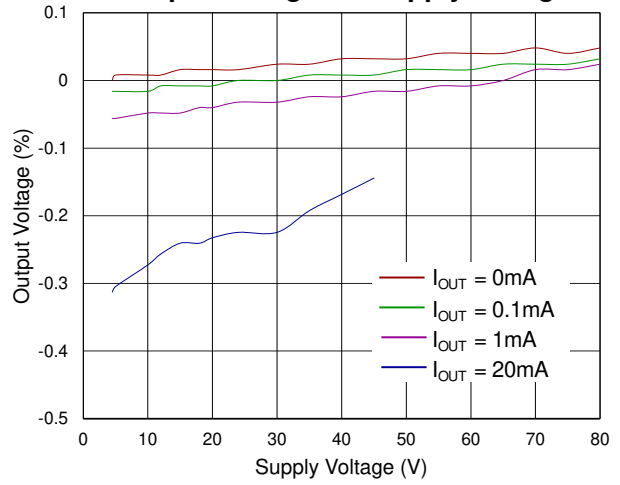
Typical Operating Characteristics



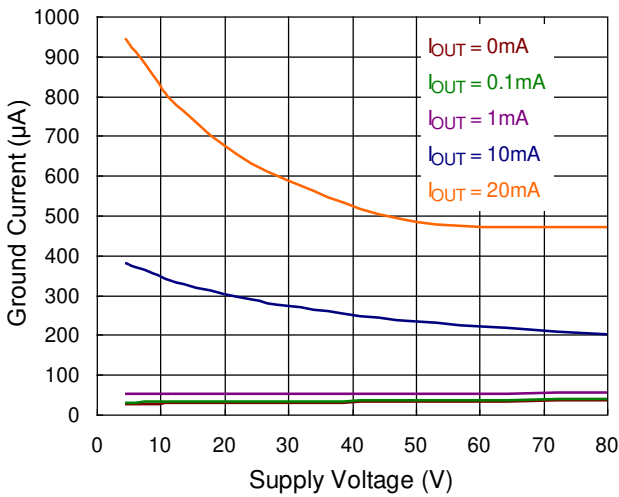
Current Limit vs. Supply Voltage



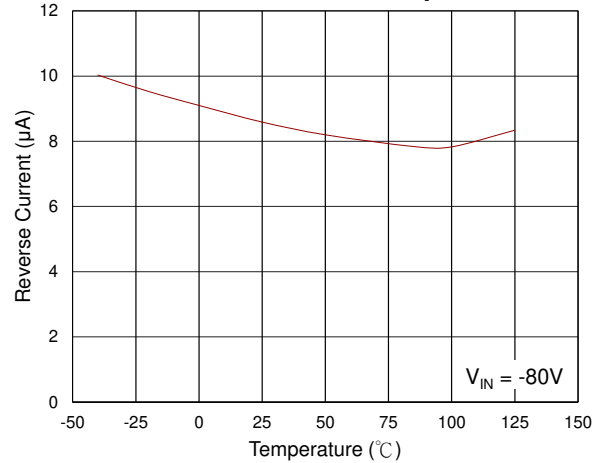
Output Voltage vs. Supply Voltage



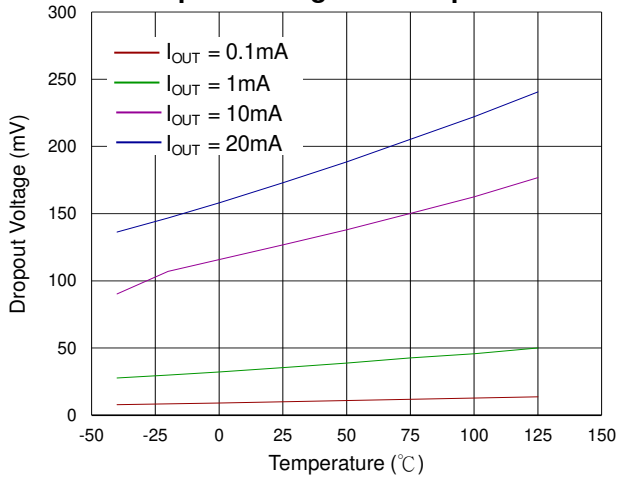
Ground Current vs. Supply Voltage



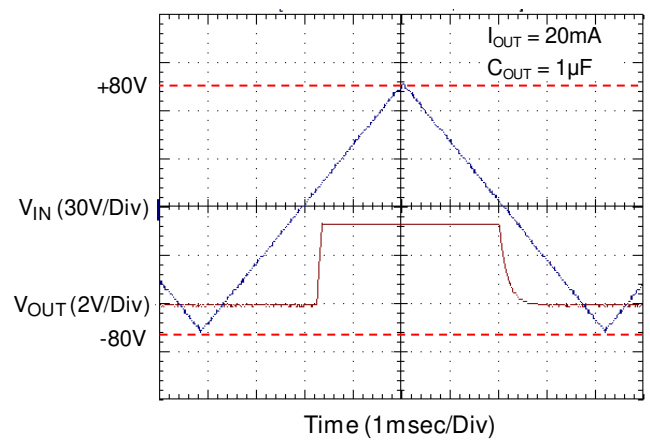
Reverse Current vs. Temperature



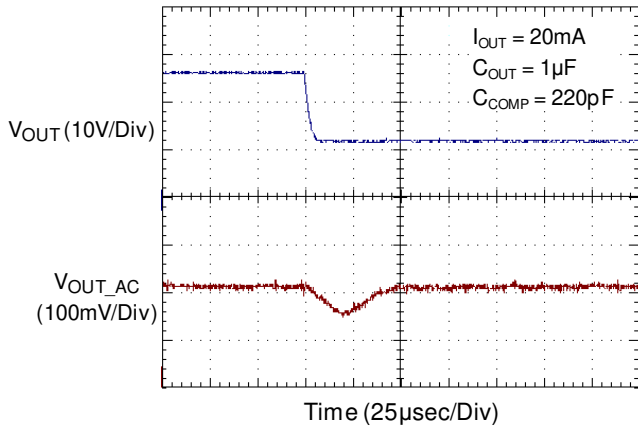
Dropout Voltage vs. Temperature



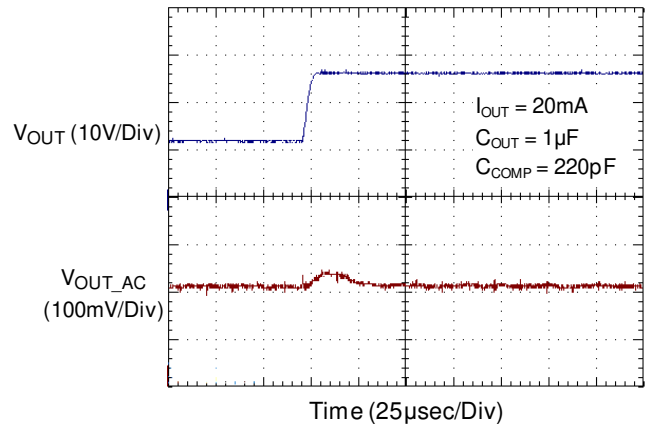
VOUT vs. VIN



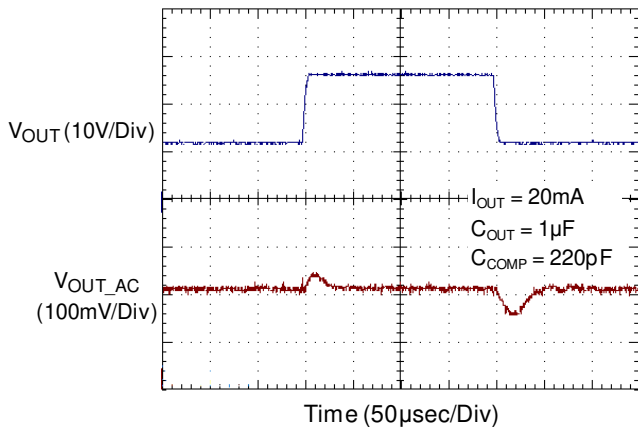
Line Transient Waveform Falling



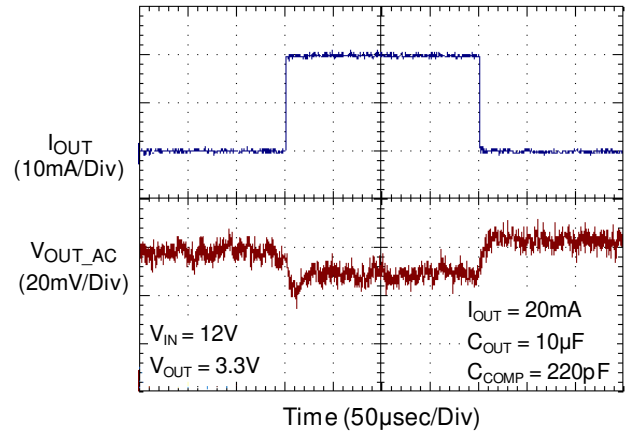
Line Transient Waveform Rising



Line Transient Waveform Full



Load Transient Waveform



Application Information

The RT9072A/B is a high input-voltage linear regulator specifically designed to minimize external components. The input voltage range is from 4.5V to 80V. The device supplies 20mA of output current with a maximum dropout voltage of 230mV.

Adjustable Output Voltage and Compensation

The adjustable output may be set to provide from 1.25V to 80V, using external feedback voltage divider resistors (Figure 1). To achieve the correct compensation (with your external FB divider, use a lower divider resistor (R2) value below 100kΩ. Calculate R1 according to the following formula : $R2 = R1 / (V_{OUT} / 1.25V - 1)$. Then, calculate the compensation capacitor (C_{COMP}) value according to the following formula : $C_{COMP} = 25\mu s / R1$

Added External NPN for High-Current Applications

Higher output currents and/or increased power dissipation are possible using an external NPN output transistor. V_{OUT} drives the base of the transistor and FB monitors the actual output voltage, as in normal applications. The output (Figure 2) can be used.

Component Selection

A low-ESR capacitor such as ceramic type must be connected between VIN and GND with short, wide traces to bypass input noise. RT9072A/B is designed to work with small input capacitor to reduce the cost from high-voltage low-ESR requirement. To guarantee a minimum 0.1μF input capacitance, a ceramic 0.18μF input capacitor with an appropriate voltage rating is recommended.

The RT9072A/B operates with any reasonable output capacitor including low-ESR ceramic types. Low-ESR aluminum and tantalum capacitor may also be used. A minimum of 1μF is recommended and much higher values are also acceptable. Connect the output capacitor between V_{OUT} and GND with short, wide traces to keep the circuit stable.

Thermal Considerations

The RT9072A/B's high input-voltage capability and high output current capability require careful use to avoid over-heating the IC and activating the internal thermal protection. To avoid thermal shutdown, do not exceed the IC's maximum operating junction temperature range of 125°C.

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 SOT-23-5 package, the thermal resistance, θ_{JA}, is 218.1°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

$$P_{D(MAX)} = (125^{\circ}C - 25^{\circ}C) / (218.1^{\circ}C/W) = 0.45W \text{ for SOT-23-5 package}$$

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.

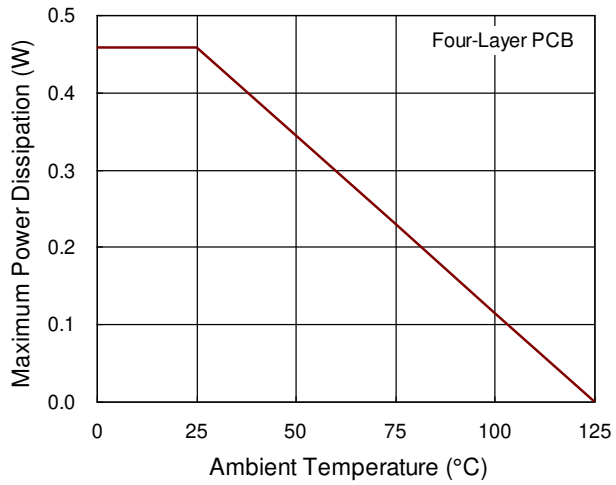


Figure 3. Derating Curve of Maximum Power Dissipation

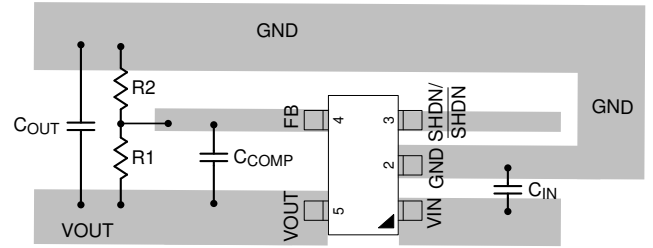
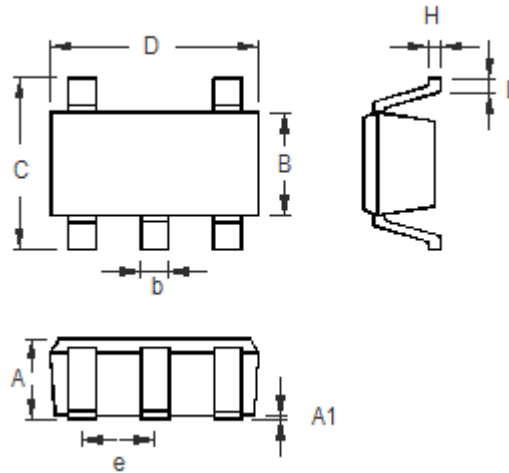


Figure 4. PCB Layout Guide

Outline Dimension



| 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 |

SOT-23-5 Surface Mount Package

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