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

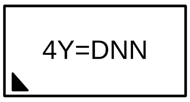
- Low Current, High Voltage Regulators
- Battery Powered Applications
- Telecom and Datacom Applications
- Automotive Applications

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**

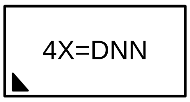
Marking Information

RT9072AGB



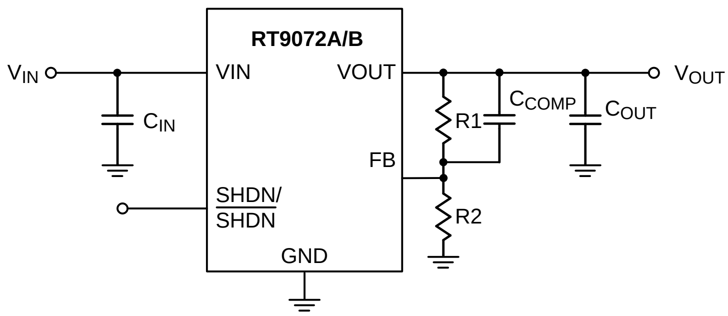
4Y= : Product Code
DNN : Date Code

RT9072BGB



4X= : Product Code
DNN : Date Code

Simplified Application Circuit



Ordering Information

RT9072A/B □□

- Package Type
  B : SOT-23-5
- Lead Plating System
  G : Green (Halogen Free and Pb Free)
- A : Low Shutdown
  B : High Shutdown

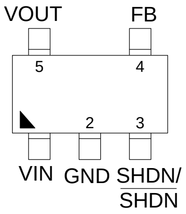
Note :

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.

Pin Configurations

(TOP VIEW)

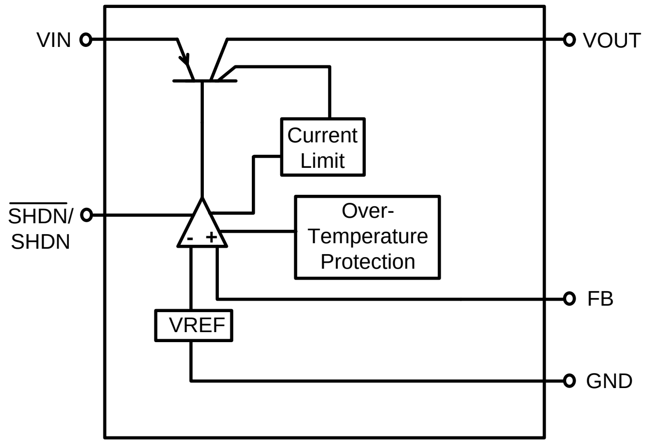


SOT-23-5

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	VIN	Power Input. Bypass VIN with a 0.18μF 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 3μA (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.
	$\overline{SHDN}$ (RT9072A)	Shutdown Control Input. Connect $\overline{SHDN}$ of RT9072A low to disable the output voltage and reduce the IC's quiescent current to 3μA (typical). Connect $\overline{SHDN}$ high to enable the output. $\overline{SHDN}$ 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 1μF 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 3μA 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 3μA 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°C
  SOT-23-5 ---------- 0.45W
- Package Thermal Resistance (Note 2)
  SOT-23-5, θ_{JA} ---------- 218.1°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°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 ---------- 4.5V to 80V
- Ambient Temperature Range ---------- –40°C to 85°C
- Junction Temperature Range ---------- –40°C to 125°C

Electrical Characteristics

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage	V_{IN}	I_{LOAD} = 20mA	4.5	--	80	V
FB Pin Voltage	V_{FB}	V_{IN} = 12V, I_{LOAD} = 100μA	1.23	1.25	1.27	μV
		100μA < I_{LOAD} < 20mA	1.21	1.25	1.29	
Line Regulation	ΔV_{LINE}	ΔV_{IN} = 4.5V to 80V, I_{LOAD} = 100μA	--	1	10	mV
Load Regulation	ΔV_{LOAD}	V_{IN} = 12V, ΔI_{LOAD} = 100μA to 20mA	--	3	25	mV
Dropout Voltage	V_{DROP}	I_{LOAD} = 100μA	--	9	50	mV
		I_{LOAD} = 1mA	--	37	100	
		I_{LOAD} = 10mA	--	130	200	
		I_{LOAD} = 20mA	--	180	230	
GND Pin Current	I_{GND}	I_{LOAD} = 0mA	--	20	30	μA
		I_{LOAD} = 20mA	--	750	1200	
Output Voltage Noise	V_{ON}	C_{OUT} = 1μF, I_{LOAD} = 20mA, BW = 10Hz 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/$\overline{SHDN}$ Pin Current	I_{SHDN}	$V_{SHDN}/V_{\overline{SHDN}}$ = 0V	--	0	0.1	μA
	$I_{\overline{SHDN}}$	$V_{SHDN}/V_{\overline{SHDN}}$ = 2V	--	0.4	2	
Quiescent Current in Shutdown	I_{SD}	V_{IN} = 6V, $V_{\overline{SHDN}}$ = 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	IV_{INr}	V_{IN} = –80V, V_{OUT} = 0V	--	--	6	mA
Reverse Output Current	IV_{OUTr}	FB connect to OUT, V_{OUT} = 1.27V, V_{IN} < 0V	--	19	40	μA
Over-Temperature Protection	T_{SD}		--	150	--	°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°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

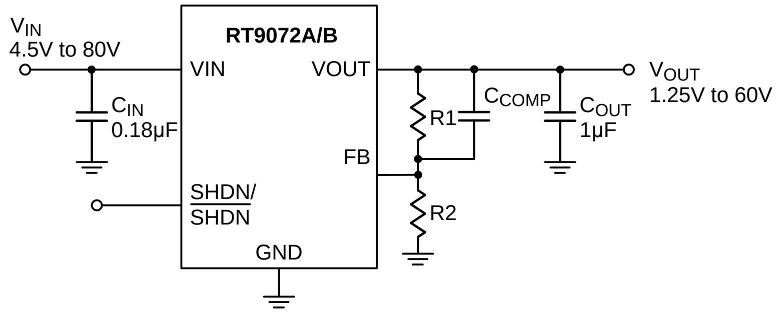


Figure 1. RT9072A/B Adjustable Output

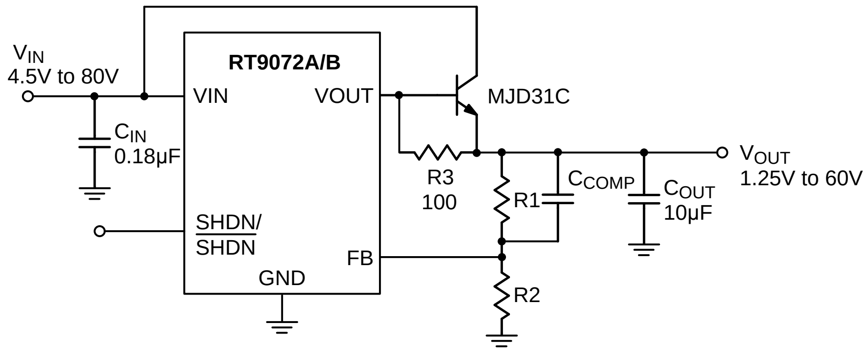
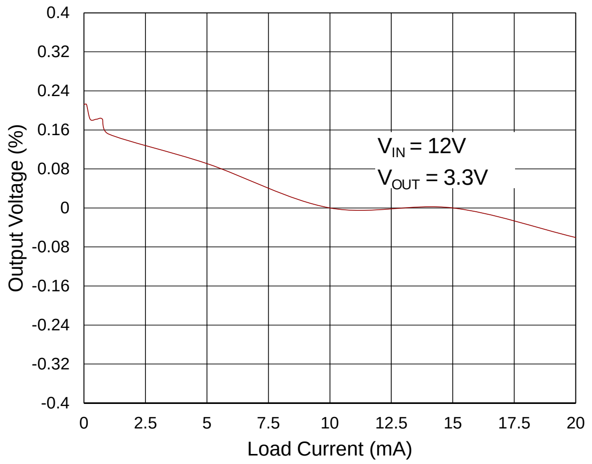


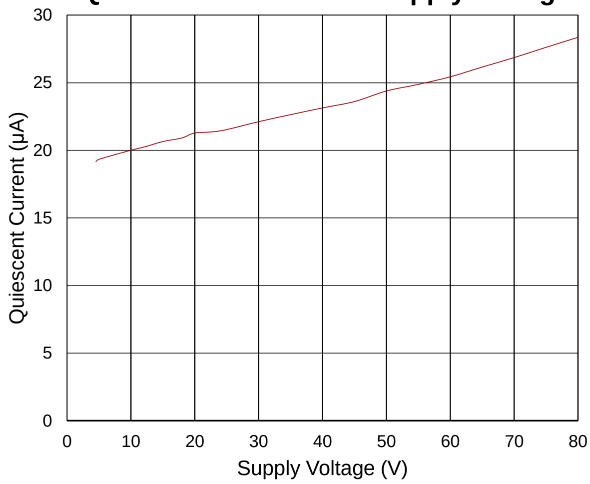
Figure 2. RT9072A/B External Transistor Application

Typical Operating Characteristics

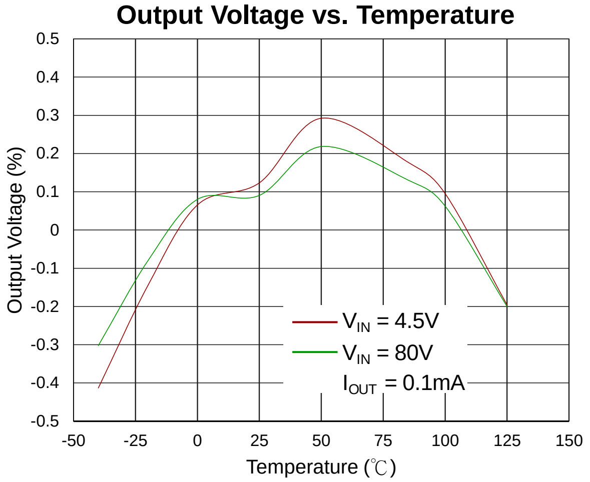
Output Voltage vs. Load Current



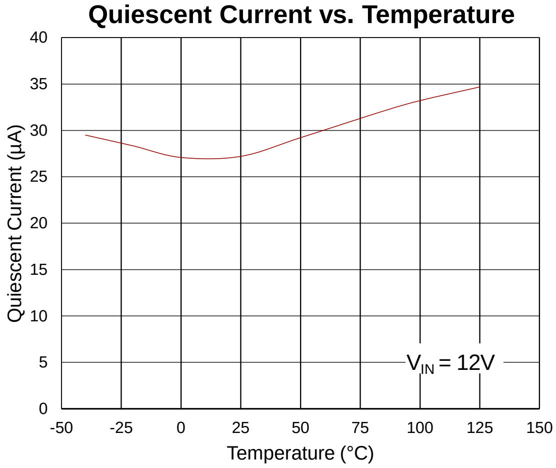
Quiescent Current vs. Supply Voltage



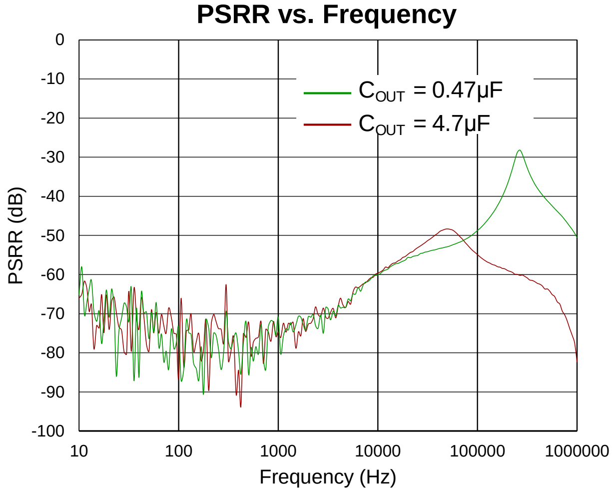
Output Voltage vs. Temperature



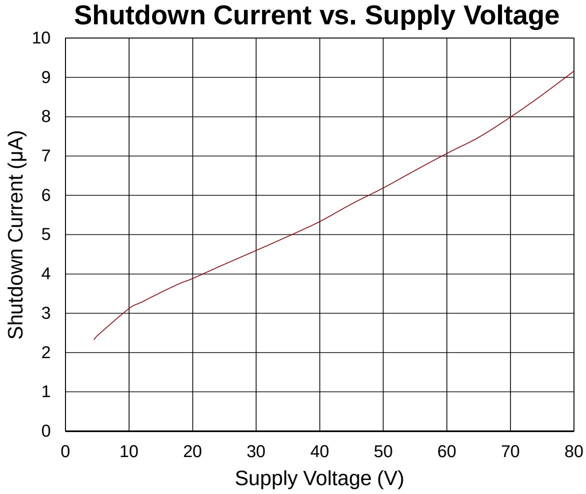
Quiescent Current vs. Temperature



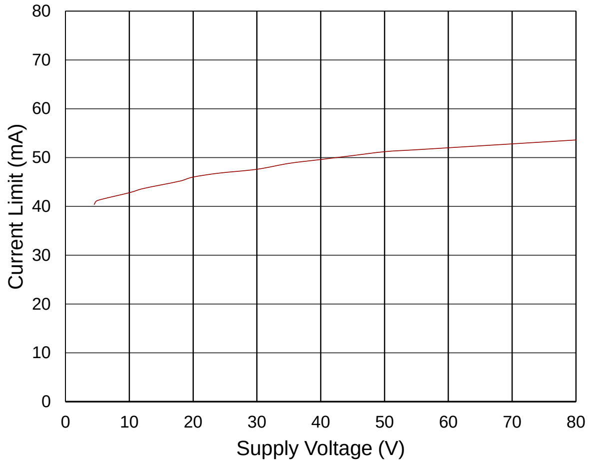
PSRR vs. Frequency



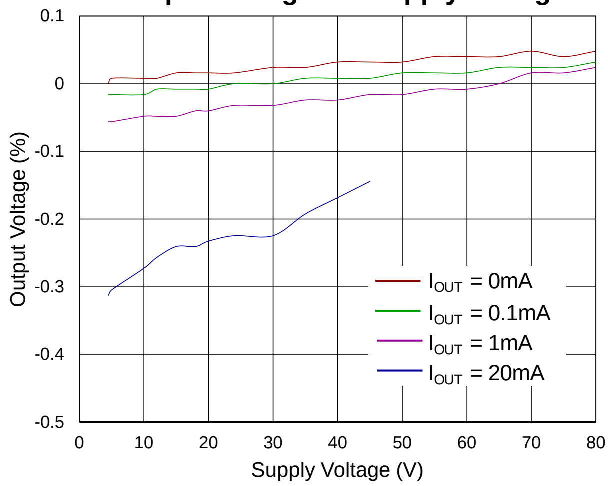
Shutdown Current vs. Supply Voltage



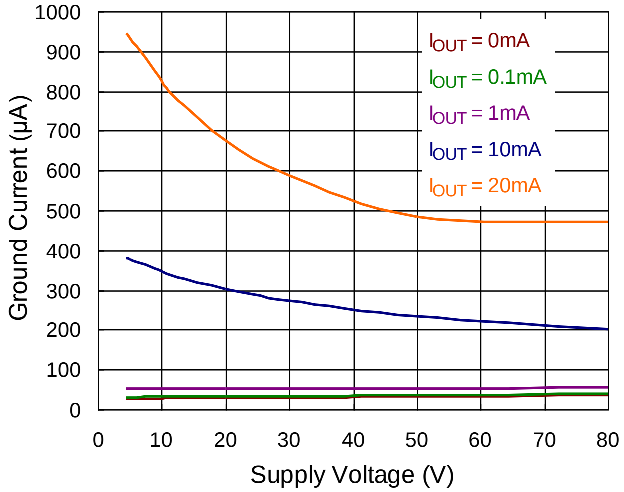
Current Limit vs. Supply Voltage



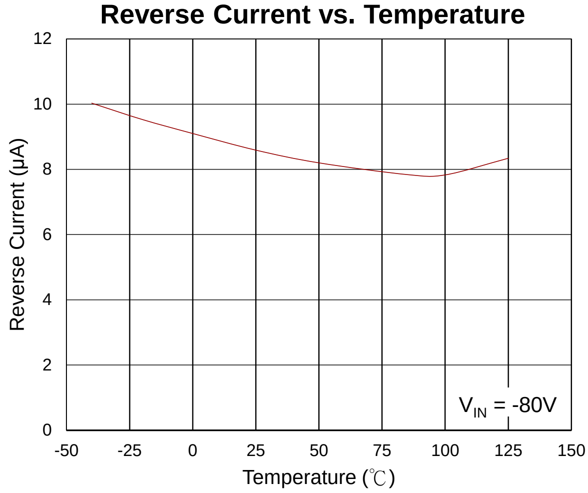
Output Voltage vs. Supply Voltage



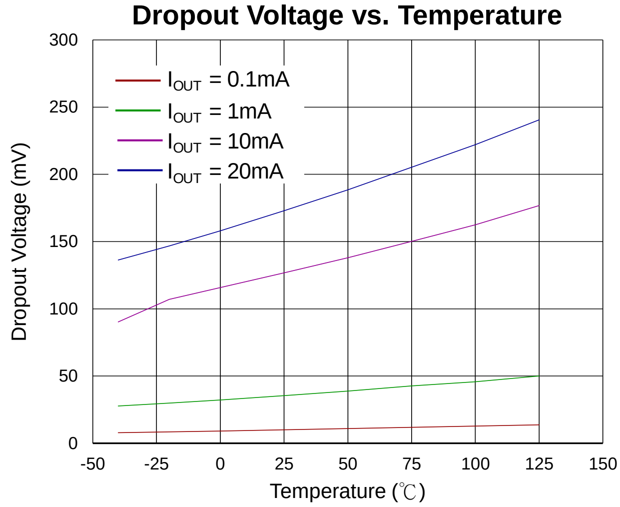
Ground Current vs. Supply Voltage



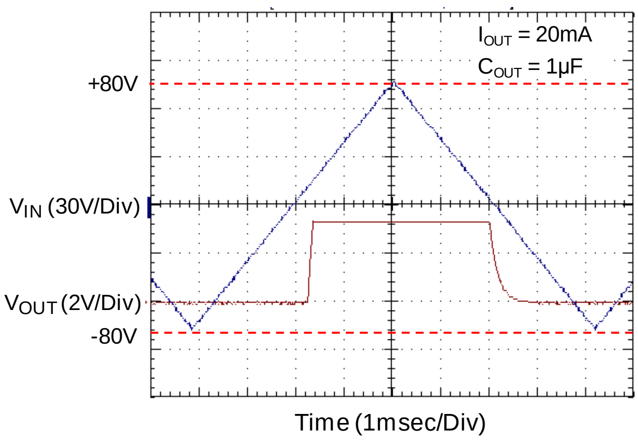
Reverse Current vs. Temperature



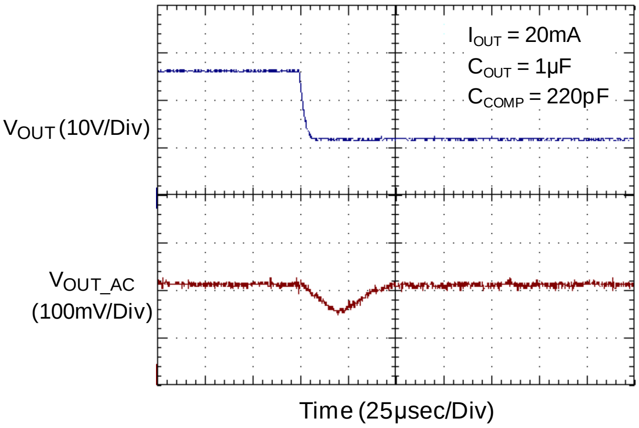
Dropout Voltage vs. Temperature



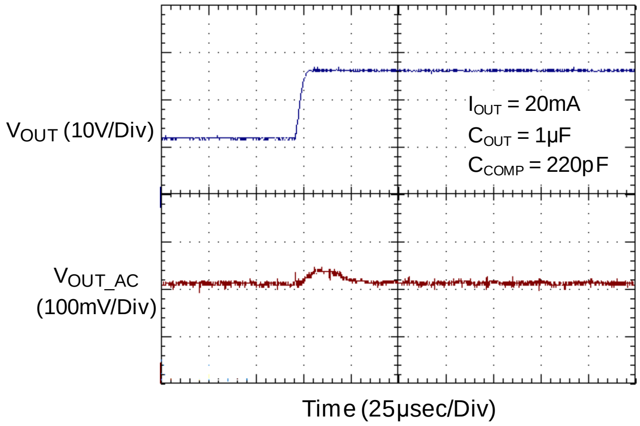
VOUT vs. VIN



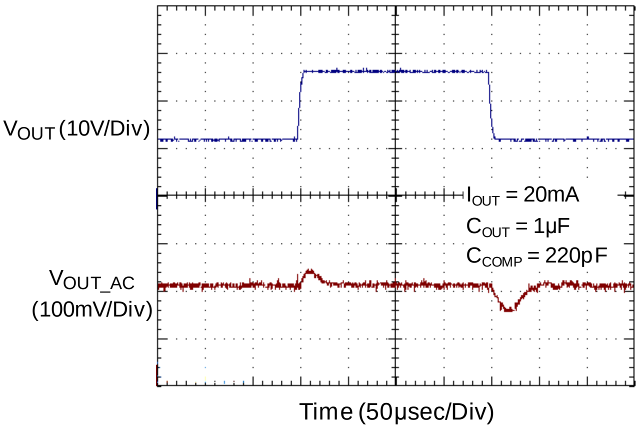
Line Transient Waveform Falling



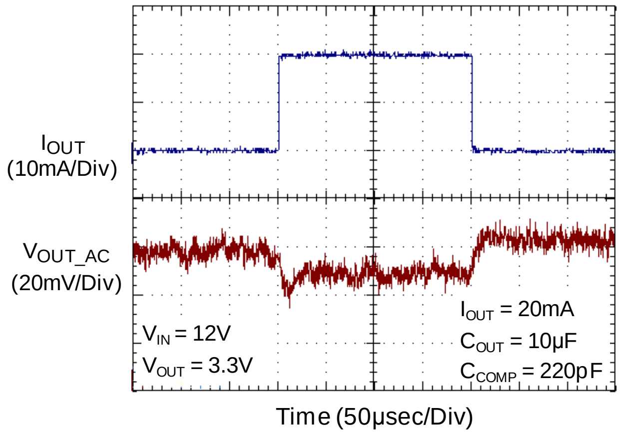
Line Transient Waveform Rising



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} = 25μs/R1

Added External NPN for High-Current Applications

Higher output currents and/or increased power dissipation are possible using an external NPN output transistor. VOUT 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 VOUT 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°C − 25°C) / (218.1°C/W) = 0.45W 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.

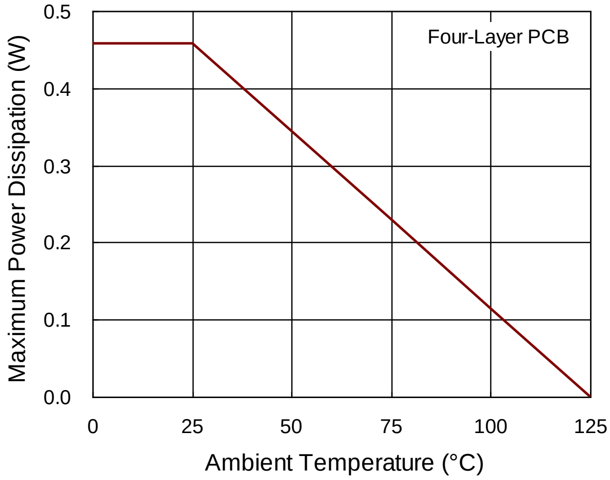


Figure 3. Derating Curve of Maximum Power Dissipation

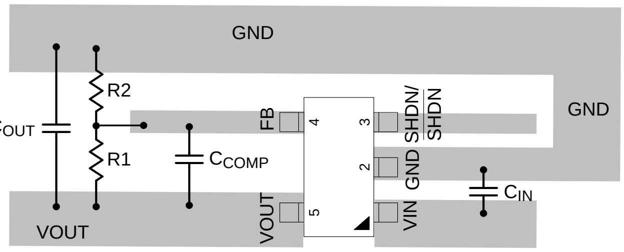
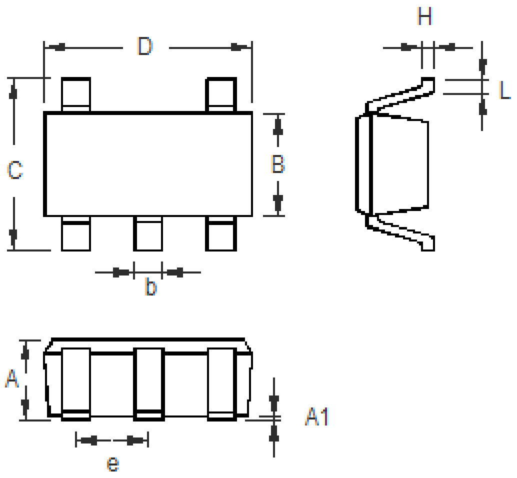


Figure 4. PCB Layout Guide

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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