Adjustable, 300mA LDO Regulator with Enable

General Description

The RT9179 is a high performance linear voltage regulator with enable high function and adjustable output with a 1.175V reference voltage. It operates from an input of 3V to 5.5V and provides output current up to 300mA with two external resistors to set the output voltage ranges from 1.175V to 4.5V.

The RT9179 has superior regulation over variations in line and load. Also it provides fast respond to step changes in load. Other features include over-current and over-temperature protection. The device has enable pin to reduce power consumption in shutdown mode.

The devices is available in the popular SOT-23-5 package.

Ordering Information

RT9179□ □

Package Type
B : SOT-23-5

Lead Plating System
P : Pb Free
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

- **300mV Dropout @ 300mA**
- **150uA Low Ground Pin Current**
- **Excellent Line and Load Regulation**
- **<1uA Standby Current in Shutdown Mode**
- **Guaranteed 300mA Output Current**
- **Stable with 1uF Input and Output Ceramic Capacitor**
- **Adjustable Output Voltage Ranges from 1.175V to 4.5V**
- **Over-Temperature/Over-Current Protection**
- **RoHS Compliant and 100% Lead (Pb)-Free**

Applications

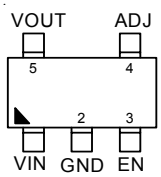
- Battery-Powered Equipment
- Graphic Card
- Peripheral Cards
- PCMCIA Card

Marking Information

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

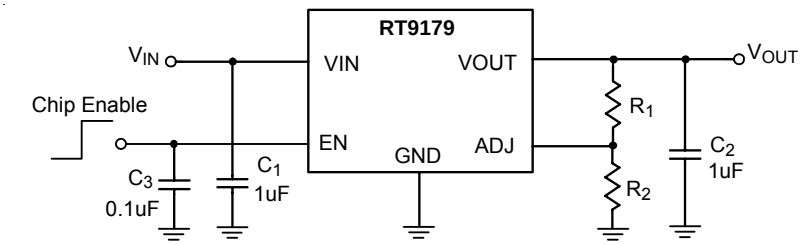
Pin Configurations

(TOP VIEW)



SOT-23-5

Typical Application Circuit



$$V_{OUT} = 1.175 \times \left(1 + \frac{R1}{R2} \right) \text{ Volts}$$

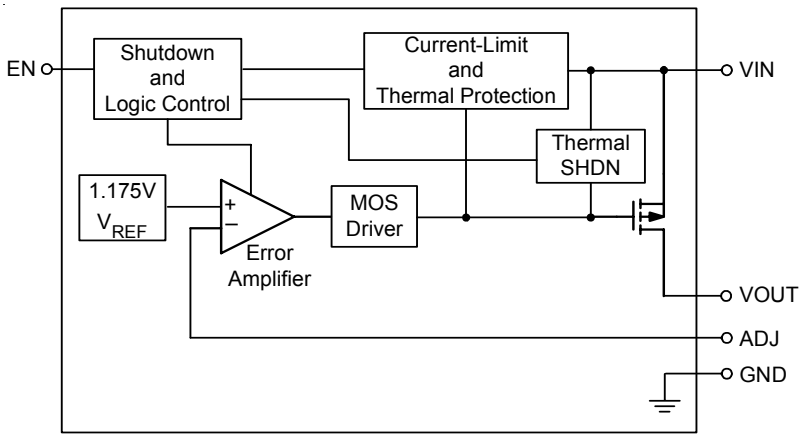
Adjustable Operation

Note: The external feedback resistors are in hundreds of OHM to hundreds of kOHM ranges.

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	VIN	Power Input Voltage
2	GND	Ground
3	EN	Chip Enable (Active High)
4	ADJ	Adjust Output Voltage. The output voltage is set by the internal feedback resistors when this pin grounded. If external feedback resistors are applied, the output voltage will be: $V_{OUT} = 1.175 \times (1 + \frac{R1}{R2})$ Volts
5	VOUT	Output Voltage

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage ---------- 6V
- Power Dissipation, P_D @ T_A = 25°C
  SOT-23-5 ---------- 0.4W
- Package Thermal Resistance (Note 2)
  SOT-23-5, θ_{JA} ---------- 250°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 Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage ---------- 3V to 5.5V
- Enable Input Voltage ---------- 0V to 5.5V
- Junction Temperature Range ---------- –40°Cto 125°C

Electrical Characteristics

(V_{IN} = V_{OUT} + 0.7V, I_{OUT} = 10uA, C_{IN} = C_{OUT} = 1uF (Ceramic), T_A = 25°C unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Reference Voltage Tolerance		V_{REF}		1.163	1.175	1.187	V
Adjust Pin Current		I_{ADJ}		--	--	10	nA
Output Voltage Range		V_{OUT}		1.175	--	4.5	V
Quiescent Current (Note 5)		I_Q	Enabled, I_{OUT} = 0mA	--	150	--	μA
Standby Current (Note 6)		I_{STBY}	V_{IN} = 5.5V, Shutdown	--	--	1	μA
Current Limit		I_{LIM}		0.5	--	--	A
Dropout Voltage (Note 7)		V_{DROP}	I_{OUT} = 10mA	--	10	--	mV
			I_{OUT} = 300mA	--	300	-	
Line Regulation		ΔV_{LINE}	V_{OUT} + 0.7V < V_{IN} < 5.5V	--	0.001	--	%/V
Thermal Shutdown Temperature		T_{SD}		--	170	--	°C
Thermal Shutdown Hysteresis		ΔT_{SD}		--	40	--	°C
EN Threshold	Logic-Low Voltage	V_{IL}	V_{IN} = 3.3V, Shutdown	--	--	0.4	V
	Logic-High Voltage	V_{IH}	V_{IN} = 3.3V, Enable	2.0	--	--	
EN Current		I_{EN}	V_{IN} = 5.5V, Enable	--	--	10	nA

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 for extended periods may remain possibility to affect device reliability.

Note 2. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

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

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

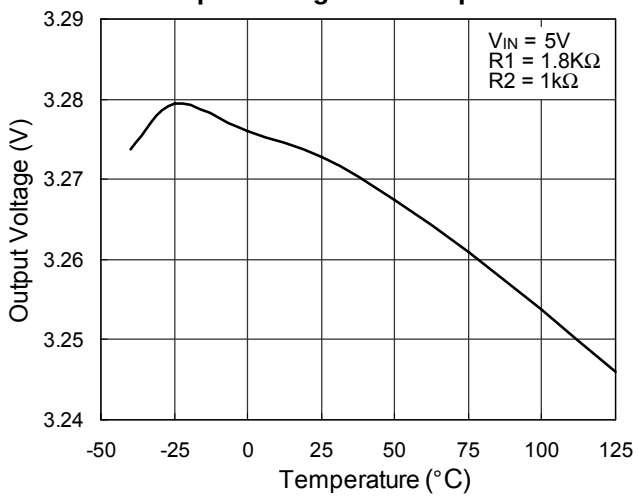
Note 5. Quiescent, or ground current, is the difference between input and output currents. It is defined by $I_Q = I_{IN} - I_{OUT}$ under no load condition (I_{OUT} = 0mA). The total current drawn from the supply is the sum of the load current plus the ground pin current.

Note 6. Standby current is the input current drawn by a regulator when the output voltage is disabled by a shutdown signal ($V_{EN} \leq$ 0.4V). It is measured with V_{IN} = 5.5V.

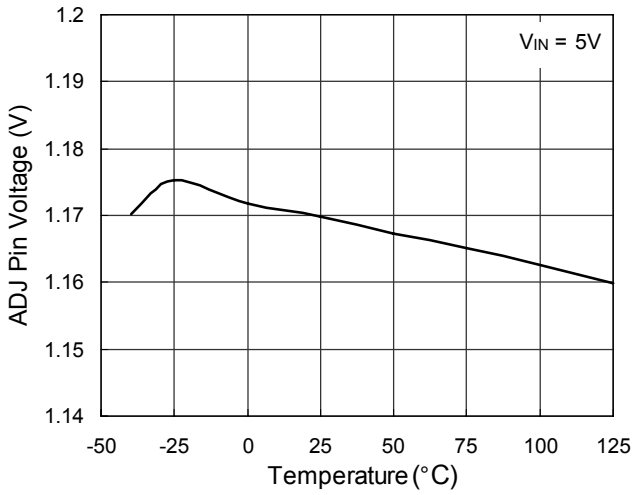
Note 7. The dropout voltage is defined as $V_{IN} - V_{OUT}$, which is measured when V_{OUT} is $V_{OUT(NORMAL)}$ – 100mV.

Typical Operating Characteristics

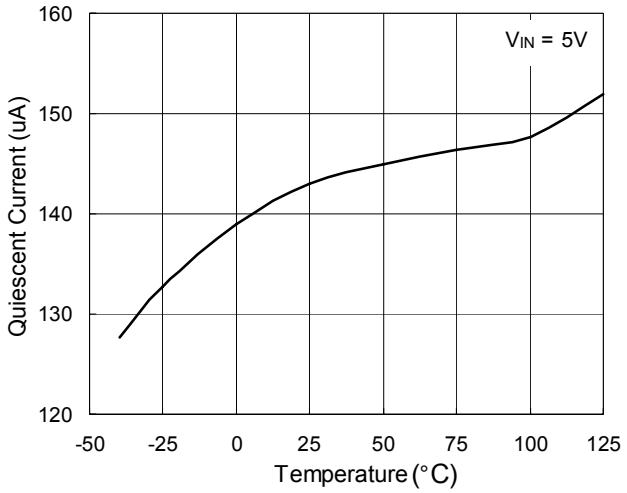
Output Voltage vs. Temperature



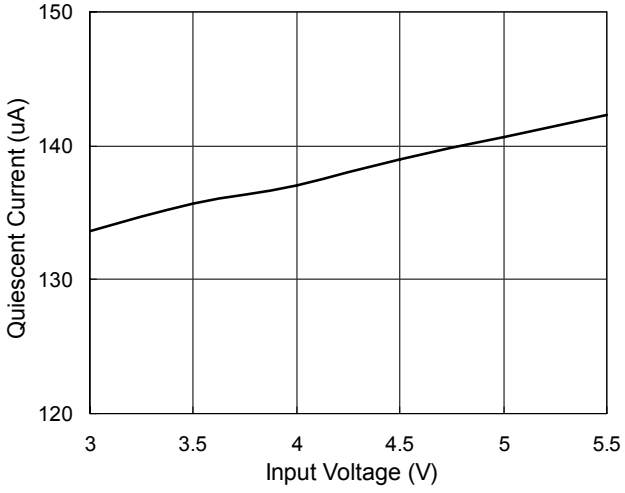
ADJ Pin Voltage vs. Temperature



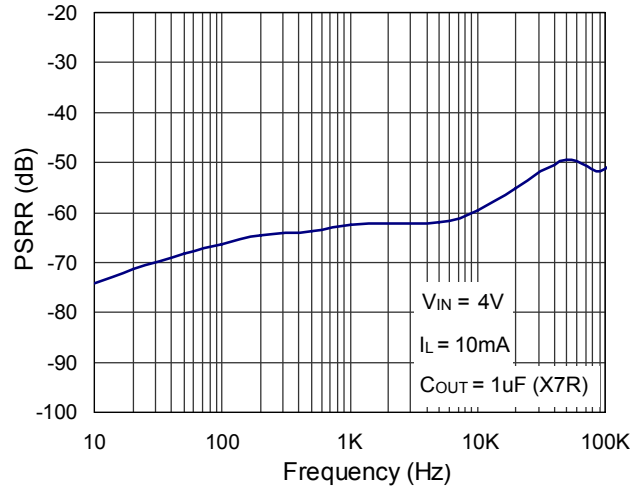
Quiescent Current vs. Temperature



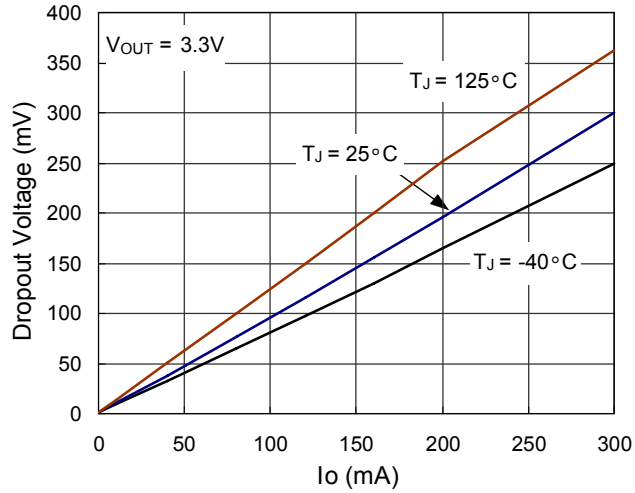
Quiescent Current vs. Input Voltage



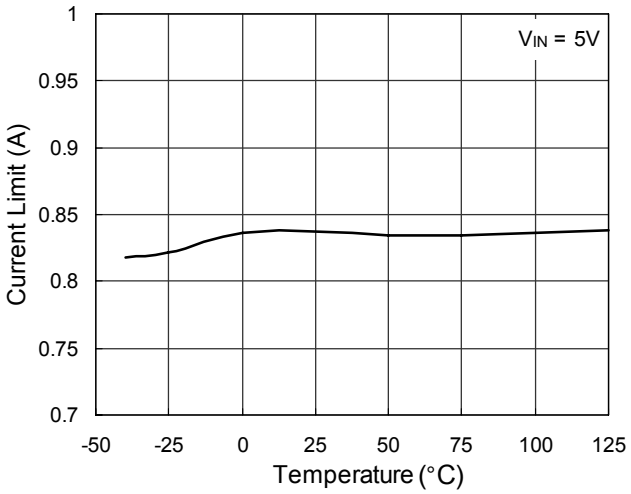
PSRR



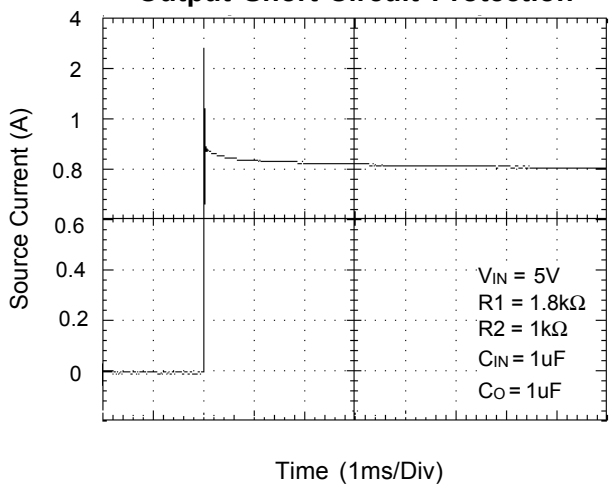
Dropout Voltage vs. Io



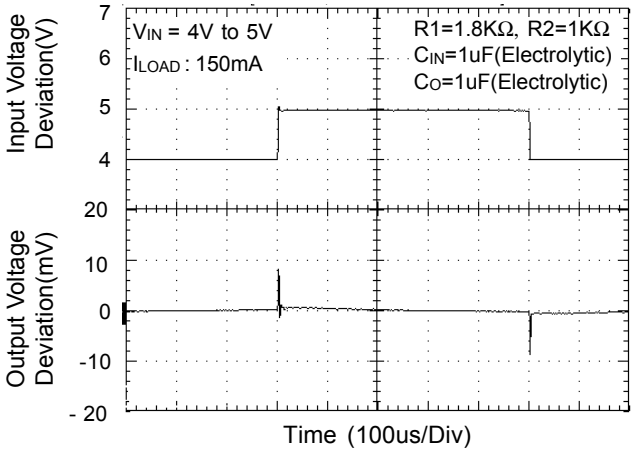
Current Limit vs. Temperature



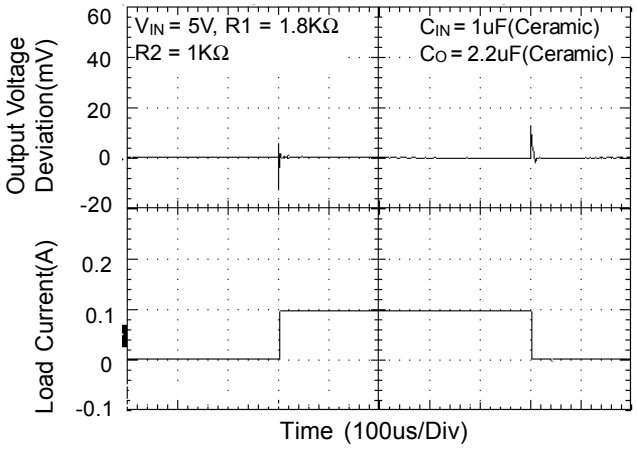
Output Short-Circuit Protection



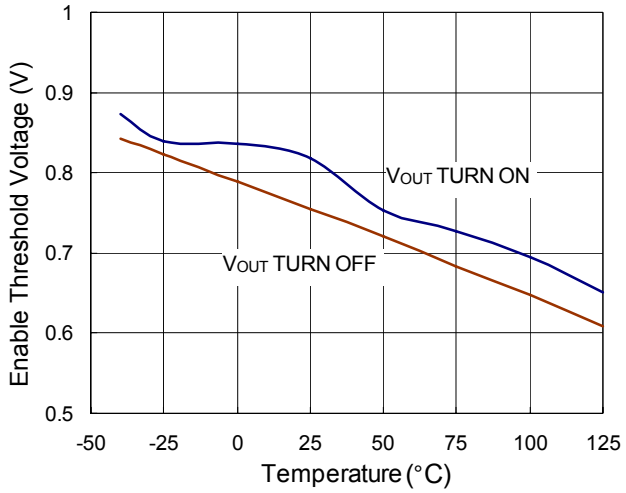
Line Transient Regulation



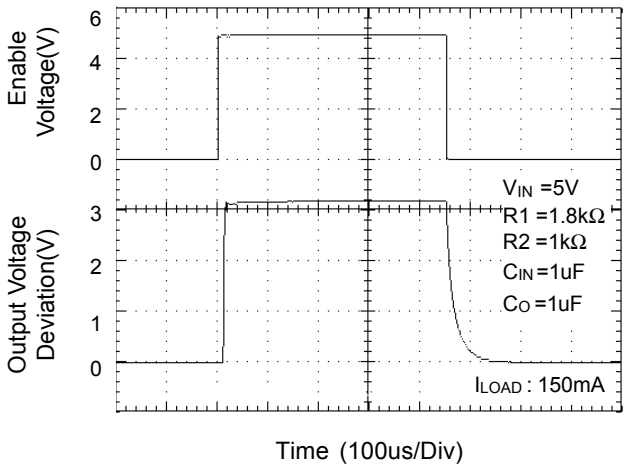
Load Transient Regulation



Enable Threshold Voltage vs. Temperature



Enable Response



Application Information

Like any low-dropout regulator, the RT9179 requires input and output decoupling capacitors. These capacitors must be correctly selected for good performance (see Capacitor Characteristics Section). Please note that linear regulators with a low dropout voltage have high internal loop gains which require care in guarding against oscillation caused by insufficient decoupling capacitance.

Input Capacitor

An input capacitance of ≅1μF is required between the device input pin and ground directly (the amount of the capacitance may be increased without limit). The input capacitor ***MUST*** be located less than 1 cm from the device to assure input stability (see PCB Layout Section). A lower ESR capacitor allows the use of less capacitance, while higher ESR type (like aluminum electrolytic) require more capacitance.

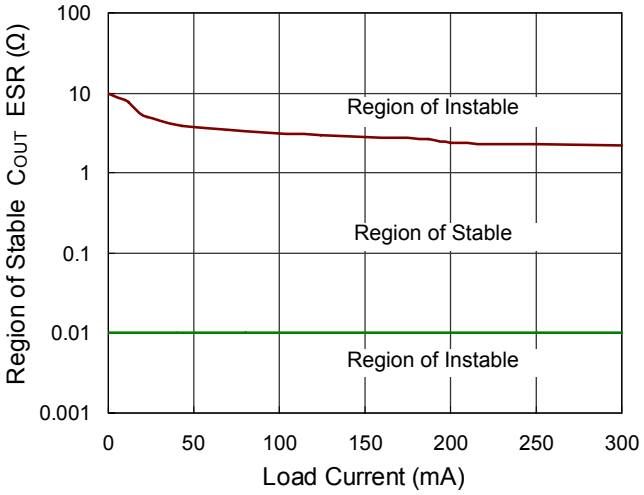
Capacitor types (aluminum, ceramic and tantalum) can be mixed in parallel, but the total equivalent input capacitance/ ESR must be defined as above to stable operation.

There are no requirements for the ESR on the input capacitor, but tolerance and temperature coefficient must be considered when selecting the capacitor to ensure the capacitance will be ≅1μF over the entire operating temperature range.

Output Capacitor

The RT9179 is designed specifically to work with very small ceramic output capacitors. The recommended minimum capacitance (temperature characteristics X7R or X5R) is 1μF to 4.7μF range with 10mΩ to 50mΩ range ceramic capacitor between LDO output and GND for transient stability, but it may be increased without limit. Higher capacitance values help to improve transient. The output capacitor's ESR is critical because it forms a zero to provide phase lead which is required for loop stability. (When using the Y5V dielectric, the minimum value of the input/output capacitance that can be used for stable over full operating temperature range is 3.3μF.)

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



No Load Stability

The device will remain stable and in regulation with no external load. This is specially important in CMOS RAM keep-alive applications

Input-Output (Dropout) Volatge

A regulator's minimum input-to-output voltage differential (dropout voltage) determines the lowest usable supply voltage. In battery-powered systems, this determines the useful end-of-life battery voltage. Because the device uses a PMOS, its dropout voltage is a function of drain-to-source on-resistance, $R_{DS(ON)}$, multiplied by the load current :

$$V_{DROPOUT} = V_{IN} - V_{OUT} = R_{DS(ON)} \times I_{OUT}$$

Current Limit

The RT9179 monitors and controls the PMOS' gate voltage, minimum limiting the output current to 0.5A. The output can be shorted to ground for an indefinite period of time without damaging the part.

Short-Circuit Protection

The device is short circuit protected and in the event of a peak over-current condition, the short-circuit control loop will rapidly drive the output PMOS pass element off. Once the power pass element shuts down, the control loop will rapidly cycle the output on and off until the average power dissipation causes the thermal shutdown circuit to respond to servo the on/off cycling to a lower frequency. Please refer to the section on thermal information for power dissipation calculations.

Capacitor Characteristics

It is important to note that capacitance tolerance and variation with temperature must be taken into consideration when selecting a capacitor so that the minimum required amount of capacitance is provided over the full operating temperature range. In general, a good tantalum capacitor will show very little capacitance variation with temperature, but a ceramic may not be as good (depending on dielectric type).
Aluminum electrolytics also typically have large temperature variation of capacitance value.

Equally important to consider is a capacitor's ESR change with temperature: this is not an issue with ceramics, as their ESR is extremely low. However, it is very important in Tantalum and aluminum electrolytic capacitors. Both show increasing ESR at colder temperatures, but the increase in aluminum electrolytic capacitors is so severe they may not be feasible for some applications.

Ceramic :

For values of capacitance in the 10μF to 100μF range, ceramics are usually larger and more costly than tantalums but give superior AC performance for by-passing high frequency noise because of very low ESR (typically less than 10mΩ). However, some dielectric types do not have good capacitance characteristics as a function of voltage and temperature.

Z5U and Y5V dielectric ceramics have capacitance that drops severely with applied voltage. A typical Z5U or Y5V capacitor can lose 60% of its rated capacitance with half of the rated voltage applied to it. The Z5U and Y5V also exhibit a severe temperature effect, losing more than 50% of nominal capacitance at high and low limits of the temperature range.

X7R and X5R dielectric ceramic capacitors are strongly recommended if ceramics are used, as they typically maintain a capacitance range within ± 20% of nominal over full operating ratings of temperature and voltage. Of course, they are typically larger and more costly than Z5U/Y5U types for a given voltage and capacitance.

Tantalum :

Solid tantalum capacitors are recommended for use on the output because their typical ESR is very close to the ideal value required for loop compensation. They also work well as input capacitors if selected to meet the ESR requirements previously listed.

Tantalums also have good temperature stability: a good quality tantalum will typically show a capacitance value that varies less than 10 to 15% across the full temperature range of 125°C to -40°C. ESR will vary only about 2X going from the high to low temperature limits.

The increasing ESR at lower temperatures can cause oscillations when marginal quality capacitors are used (if the ESR of the capacitor is near the upper limit of the stability range at room temperature).

Aluminum :

This capacitor type offers the most capacitance for the money. The disadvantages are that they are larger in physical size, not widely available in surface mount, and have poor AC performance (especially at higher frequencies) due to higher ESR and ESL.

Compared by size, the ESR of an aluminum electrolytic is higher than either Tantalum or ceramic, and it also varies greatly with temperature. A typical aluminum electrolytic can exhibit an ESR increase of as much as 50X when going from 25°C down to -40°C.

It should also be noted that many aluminum electrolytics only specify impedance at a frequency of 120Hz, which indicates they have poor high frequency performance. Only aluminum electrolytics that have an impedance specified at a higher frequency (between 20kHz and 100kHz) should be used for the device. Derating must be applied to the manufacturer's ESR specification, since it is typically only valid at room temperature.

Any applications using aluminum electrolytics should be thoroughly tested at the lowest ambient operating temperature where ESR is maximum.

Thermal Considerations

The RT9179 can deliver a current of up to 300mA over the full operating junction temperature range. However, the maximum output current must be derated at higher ambient temperature to ensure the junction temperature does not exceed 125°C. With all possible conditions, the junction temperature must be within the range specified under operating conditions. Power dissipation can be calculated based on the output current and the voltage drop across regulator.

$$P_D = (V_{IN} - V_{OUT}) I_{OUT} + V_{IN} I_{GND}$$

The final operating junction temperature for any set of conditions can be estimated by the following thermal equation :

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

Where $T_{J\,(MAX)}$ is the maximum junction temperature of the die (125°C) and T_A is the maximum ambient temperature. The junction to ambient thermal resistance (θ_{JA}) for SOT-23-5 package at recommended minimum footprint is 250°C/W (θ_{JA} is layout dependent). Visit our website in which "Recommended Footprints for Soldering Surface Mount Packages" for detail.

PCB Layout

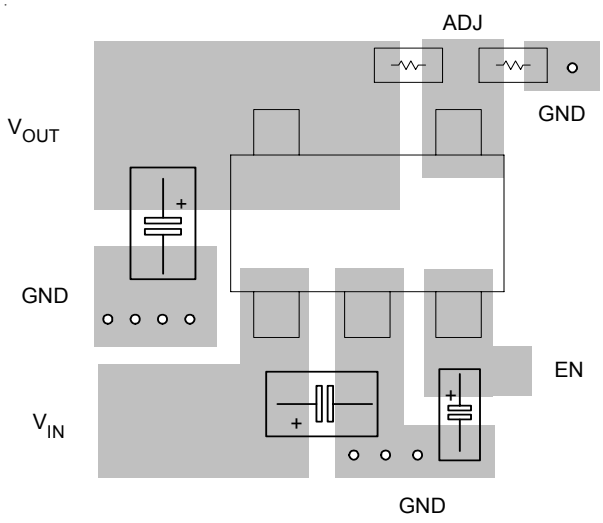
Good board layout practices must be used or instability can be induced because of ground loops and voltage drops. The input and output capacitors ***MUST*** be directly connected to the input, output, and ground pins of the device using traces which have no other currents flowing through them.

The best way to do this is to layout C_{IN} and C_{OUT} near the device with short traces to the V_{IN}, V_{OUT}, and ground pins. The regulator ground pin should be connected to the external circuit ground so that the regulator and its capacitors have a "single point ground".

It should be noted that stability problems have been seen in applications where "vias" to an internal ground plane were used at the ground points of the device and the input and output capacitors. This was caused by varying ground potentials at these nodes resulting from current flowing through the ground plane.

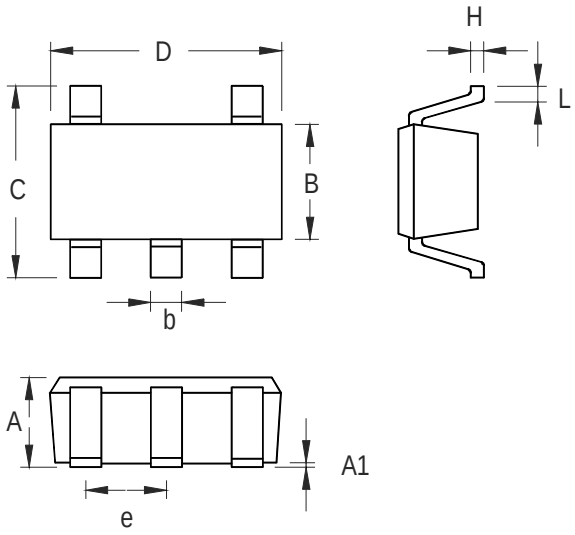
Using a single point ground technique for the regulator and it's capacitors fixed the problem. Since high current flows through the traces going into V_{IN} and coming from V_{OUT}, Kelvin connect the capacitor leads to these pins so there is no voltage drop in series with the input and output capacitors.

Optimum performance can only be achieved when the device is mounted on a PC board according to the diagram below:



SOT-23-5 Board Layout

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	0.102	0.254	0.004	0.010
L	0.356	0.610	0.014	0.024

SOT-23-5 Surface Mount Package

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