RICHTEK® **RTQ6060**

36V High-Side or Low-Side Measurement, Bidirectional, Voltage-Output, Zero-Drift Current Monitor

1 General Description

The RTQ6060 series comprises high-precision current monitors that are commonly used in most current-reporting systems and current-sensing circuits for precision current measurement and system optimization. These devices can sense a low-voltage drop (10mV) across the shunt resistor at a common-mode voltage ranging from –0.3V to 36V. They feature extremely low input offset, offset drift, gain error, and gain drift, all of which are achieved by zero-drift architecture. Six fixed gains of 50, 75, 100, 200, 500, and 1000V/V are available to accommodate different current scaling applications.

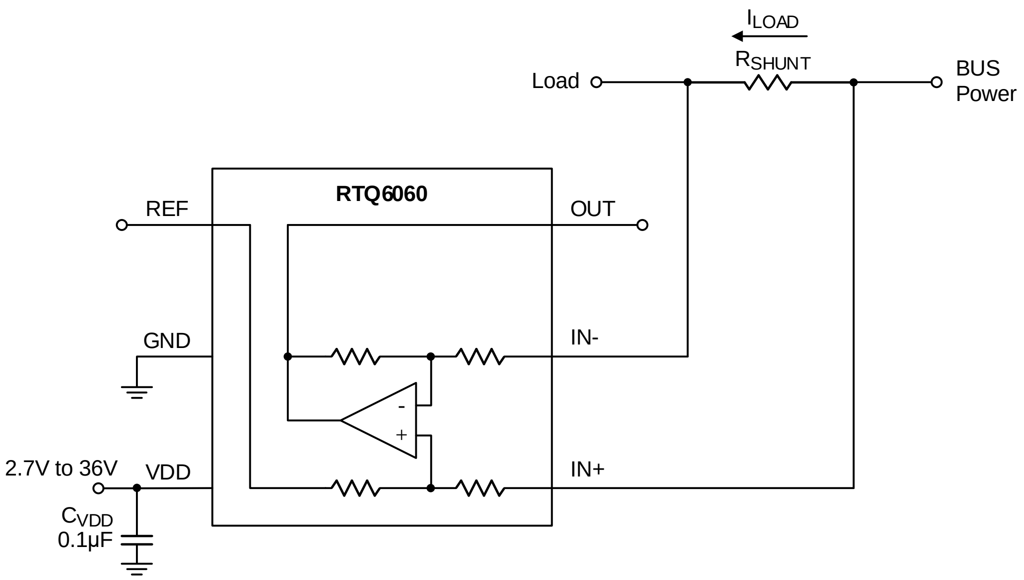
These devices operate from a single power supply ranging from 2.7V to 36V and draw a maximum supply current of 100μA. The RTQ6060 is available in an SC-70-6 package.

The recommended ambient temperature range is –40°C to 125°C.

2 Features

- **Wide Common-Mode Range: –0.3V to 36V**
- **Bidirectional Current Sensing**
- **High-Side or Low-Side Sensing**
- **Offset Voltage: ±35μV (Maximum, RTQ6060A-200)**
- **Accuracy**
  - **Gain Error (Maximum Over-Temperature)**
    - **±0.4% (RTQ6060A)**
    - **±0.8% (RTQ6060B)**
  - **Temperature Drift**
    - **0.5μV/°C Offset Drift (Maximum)**
    - **10ppm/°C Gain Drift (Maximum)**
- **Choice of Gains**
  - **RTQ6060-50: 50V/V**
  - **RTQ6060-75: 75V/V**
  - **RTQ6060-100: 100V/V**
  - **RTQ6060-200: 200V/V**
  - **RTQ6060-500: 500V/V**
  - **RTQ6060-1000: 1000V/V**
- **Quiescent Current: 100μA (Maximum)**
- **Package: 6-Pin SC-70**

3 Simplified Application Circuit



$V_{OUT} = (I_{LOAD} \times R_{SHUNT})\ \text{Gain} + V_{REF}$

4 Ordering Information

RTQ6060 □□-□□□

Packing
B: Pin 1 Orientation
(Quadrant 3, Follow EIA-481)

Gain (V/V)
50
75
100
200
500
1000

Product Grade
T: Industrial Grade

Package Type(1)
D: SC-70-6

Accuracy Grade
A: High
B: Standard

Note 1.

Richtek products are Richtek Green Policy compliant and marked with (1) indicates compatible with the current requirements of IPC/JEDEC J-STD-020.

5 Applications

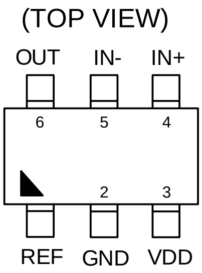
- Servers, Storage, and Network Equipment
- Portable, Battery-Powered Systems
- Point of Load (POL) Power Modules
- Notebook Computers
- Telecom Equipment

6 Marking Information

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

Table of Contents

7 Pin Configuration

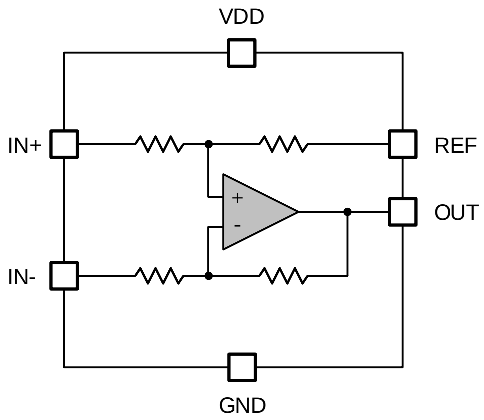


SC-70 -6

8 Functional Pin Description

Pin Name	Pin No.	I/O	Pin Function
REF	1	Analog input	Reference voltage input. The input voltage range is from 0V to VDD.
GND	2	Analog ground	Power ground.
VDD	3	Power input	Power supply. The input voltage range is from 2.7V to 36V. Connect an input capacitor of 0.1μF, X7R or larger ceramic capacitor between this pin and GND.
IN+	4	Analog input	Shunt voltage positive input. Connect this pin to the supply side of the shunt resistor.
IN-	5	Analog input	Shunt voltage negative input. Connect this pin to the load side of the shunt resistor.
OUT	6	Analog output	Voltage output. V_{OUT} is proportional to V_{SENSE} (IN+ – IN-).

9 Functional Block Diagram



10 Absolute Maximum Ratings

(Note 2, Note 3, Note 4)

- Supply Input Voltage, V_{DD} ---------- –0.3V to 39.6V
- Common-Mode Voltage, V_{IN+} ---------- –0.3V to 39.6V
- Common-Mode Voltage, V_{IN-} ---------- –0.3V to 39.6V
- Differential Shunt Voltage, (V_{IN+}) – (V_{IN-}) ---------- –39.6V to 39.6V
- Reference Input Voltage, V_{REF} ---------- –0.3V to (VDD + 0.3V)
- Output Voltage, V_{OUT} ---------- –0.3V to (VDD + 0.3V)
- Power Dissipation, P_D @ T_A = 25°C
  SC-70-6 ---------- 0.54W
- Package Thermal Resistance (Note 5)
  SC-70-6, θ_{JA} ---------- 183.9°C/W
  SC-70-6, θ_{JC} ---------- 83.8°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 160°C
- Storage Temperature Range ---------- –65°C to 150°C

Note 2. Stresses beyond those listed under "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 3. V_{IN+} and V_{IN-} are the voltages at the IN+ and IN– pins, respectively. V_{CM} is the common-mode voltage, which includes both V_{IN+} and V_{IN-}.

Note 4. It should be fully connected to the ground terminal.

Note 5. θ_{JA} is simulated 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. θ_{JC} is simulated at the bottom of the package.

11 ESD Ratings

(Note 6)

- ESD Susceptibility
  HBM (Human Body Model) ---------- 3.5kV
  CDM (Charged Device Model) ---------- 1kV

Note 6. Devices are ESD sensitive. Handling precautions are recommended.

12 Recommended Operating Conditions

(Note 7)

- Supply Input Voltage, V_{DD} ---------- 5V
- Common-Mode Voltage, V_{IN+}, V_{IN-} ---------- 12V
- Ambient Temperature Range ---------- –40°C to 125°C

Note 7. Operation of the IC beyond its specified operating range is not guaranteed to be functional.

13 Electrical Characteristics

(T_A = 25°C, V_{SENSE} = V_{IN+} – V_{IN-}.

RTQ6060-50, RTQ6060-75, RTQ6060-100, and RTQ6060-200: V_{DD} = 5V, V_{IN+} = 12V, and V_{REF} = V_{DD} / 2, unless otherwise specified.

RTQ6060-500 and RTQ6060-1000: V_{DD} = 12V, V_{IN+} = 12V, and V_{REF} = V_{DD} / 2, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supply						
Operating Supply Range	V_{DD}	T_A = –40°C to 125°C	2.7	--	36	V
Quiescent Current	I_Q	V_{SENSE} = 0mV	--	65	100	µA
		T_A = –40°C to 125°C	--	--	115	µA
Input						
Common-Mode Input Range (Note 8)	V_{CM}	T_A = –40°C to 125°C	–0.3	--	36	V
Common-Mode Rejection	CMRR	T_A = –40°C to 125°C V_{IN+} = 0V to 36V, V_{SENSE} = 0mV RTQ6060-75 RTQ6060-100 RTQ6060-200 RTQ6060-500 RTQ6060-1000	105	140	--	dB
		T_A = –40°C to 125°C V_{IN+} = 0V to 36V, V_{SENSE} = 0mV RTQ6060-50	100	120	--	
Offset Voltage, RTI (Note 9)	V_{OS}	V_{SENSE} = 0mV RTQ6060A-50	--	±5	±100	µV
		V_{SENSE} = 0mV RTQ6060A-75 RTQ6060A-100	--	±1	±60	
		V_{SENSE} = 0mV RTQ6060A-200 RTQ6060A-500 RTQ6060A-1000	--	±0.55	±35	
		V_{SENSE} = 0mV RTQ6060B	--	±5	±150	
Offset Voltage, RTI vs. Temperature		T_A = –40°C to 125°C	--	0.1	0.5	µV/°C
Power Supply Ripple Rejection, RTI	PSRR	V_{DD} = 2.7V to 36V V_{IN+} = 18V V_{SENSE} = 0mV	--	±0.1	±10	µV/V
Input Bias Current	I_{BIAS}	V_{SENSE} = 0mV	15	28	35	µA
Input Offset Current	I_{OS}	V_{SENSE} = 0mV	--	±0.02	--	µA

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Output						
Gain	G	RTQ6060-50	--	50	--	V/V
		RTQ6060-75	--	75	--	
		RTQ6060-100	--	100	--	
		RTQ6060-200	--	200	--	
		RTQ6060-500	--	500	--	
		RTQ6060-1000	--	1000	--	
Gain Error	E_G	T_A = –40°C to 125°C V_{SENSE} = –5mV to 5mV RTQ6060A	--	±0.02	±0.4	%
		T_A = –40°C to 125°C V_{SENSE} = –5mV to 5mV RTQ6060B	--	±0.03	±0.8	
Gain Error vs. Temperature		T_A = –40°C to 125°C	--	3	10	ppm/°C
Nonlinearity Error		V_{SENSE} = –5mV to 5mV	--	±0.01	--	%
Maximum Capacitive Load		No sustained oscillation	--	1	--	nF
Swing to V+ Power-Supply Rail		T_A = –40°C to 125°C R_L = 10kΩ to GND	--	V_{DD} – 0.05	V_{DD} – 0.2	V
Swing to GND		T_A = –40°C to 125°C R_L = 10kΩ to GND	--	GND + 0.005	GND + 0.05	V
Frequency Response						
Bandwidth (Note 10)	BW	C_{LOAD} = 10pF RTQ6060-50	--	80	--	kHz
		C_{LOAD} = 10pF RTQ6060-75	--	40	--	
		C_{LOAD} = 10pF RTQ6060-100	--	30	--	
		C_{LOAD} = 10pF RTQ6060-200	--	14	--	
		C_{LOAD} = 10pF RTQ6060-500	--	7	--	
		C_{LOAD} = 10pF RTQ6060-1000	--	4	--	
Slew Rate	SR	T_A = –40°C to 125°C	--	0.4	--	V/μs
Voltage Noise Density (Note 10)			--	25	--	$nV / \sqrt{Hz}$

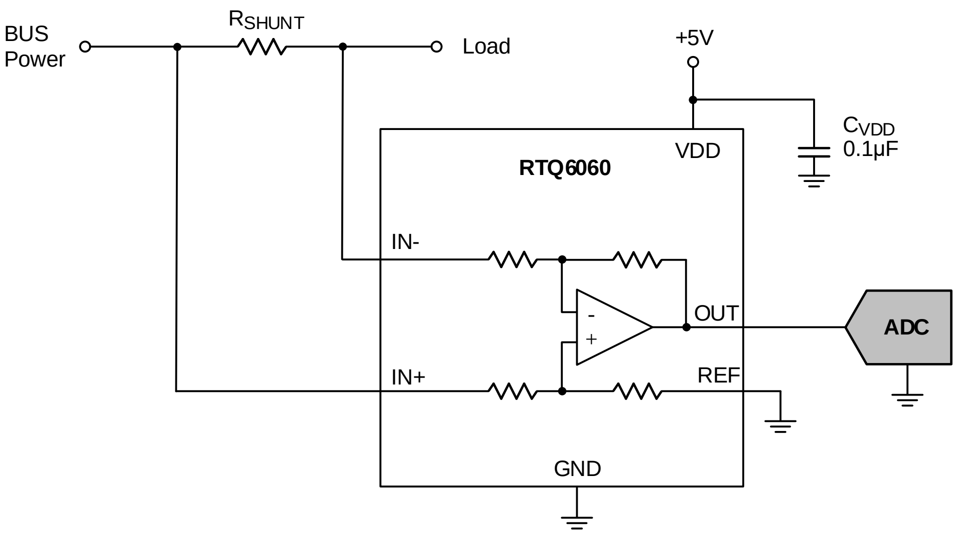
Note 8. VCM is the common-mode voltage, which includes both VIN+ and VIN-.

Note 9. RTI = Referred-to-Input.

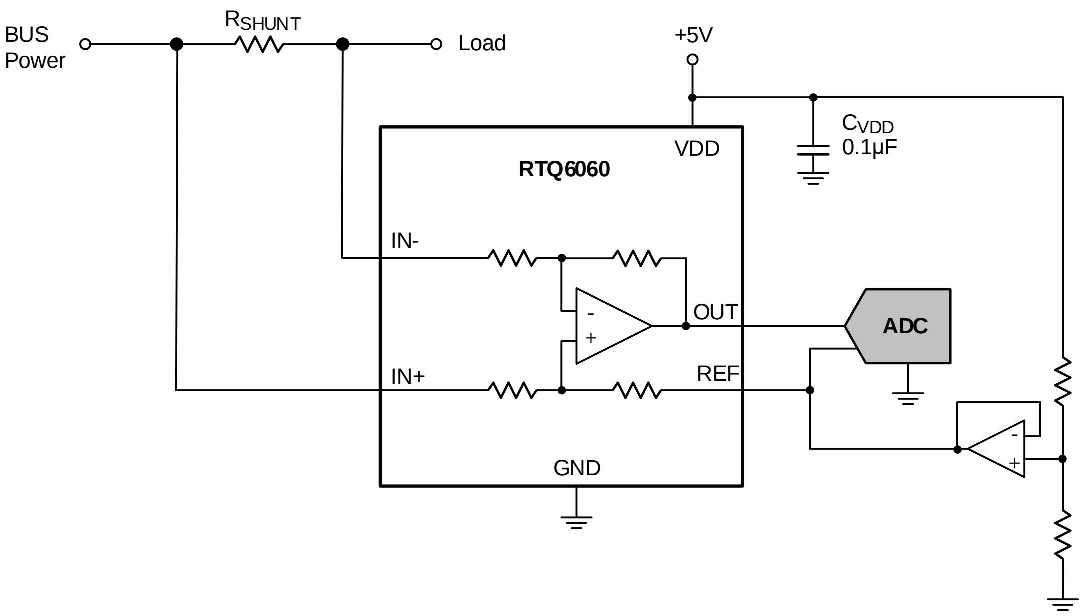
Note 10. Guaranteed by design.

14 Typical Application Circuit

14.1 Unidirectional Configuration

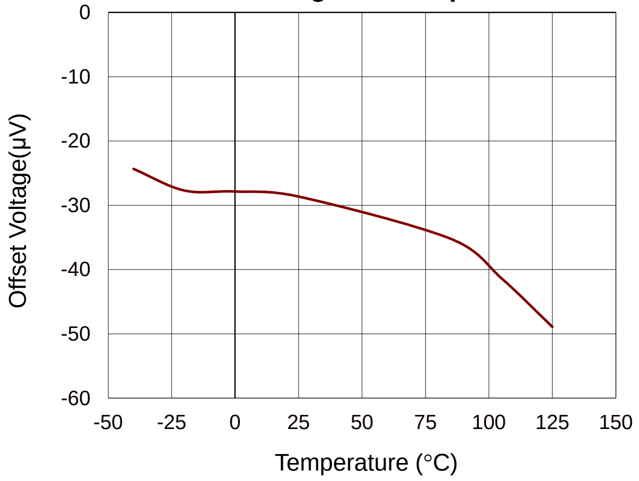


14.2 Bidirectional Configuration

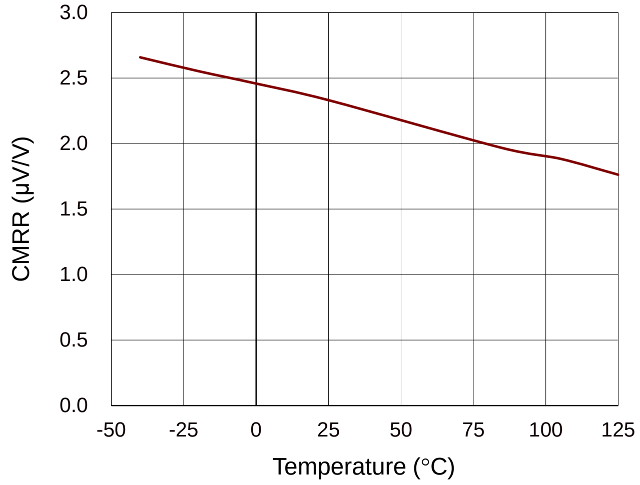


15 Typical Operating Characteristics

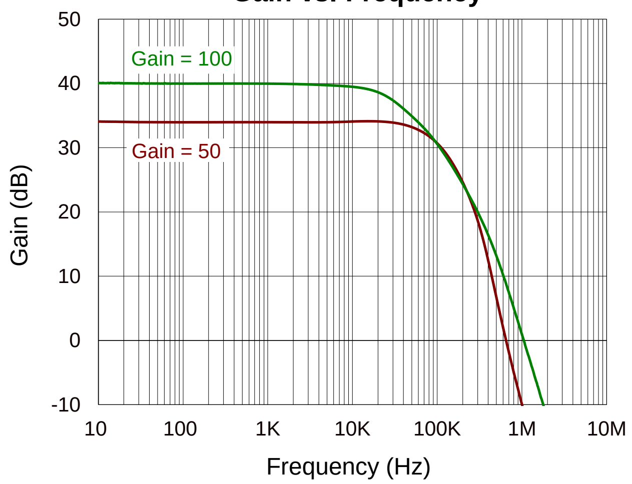
Offset Voltage vs. Temperature



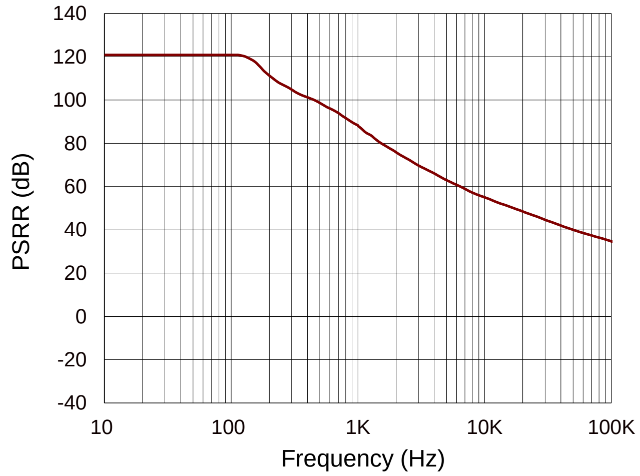
Common-Mode Rejection Ratio (CMRR) vs. Temperature



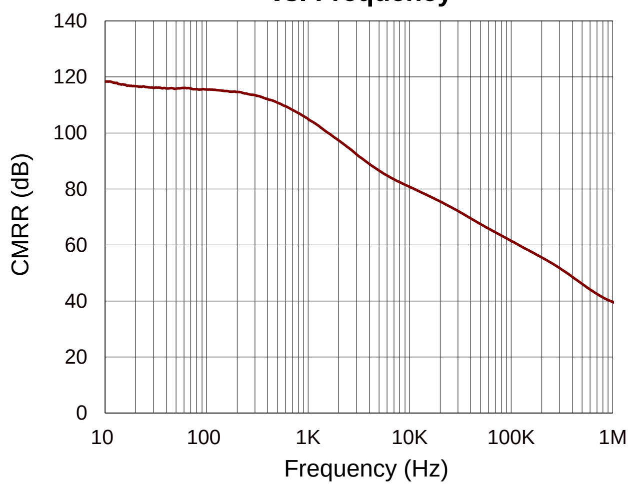
Gain vs. Frequency



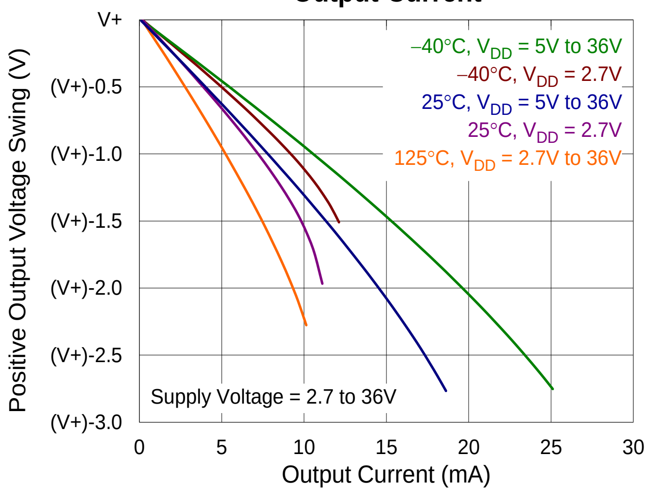
Power-Supply Rejection Ratio (PSRR) vs. Frequency



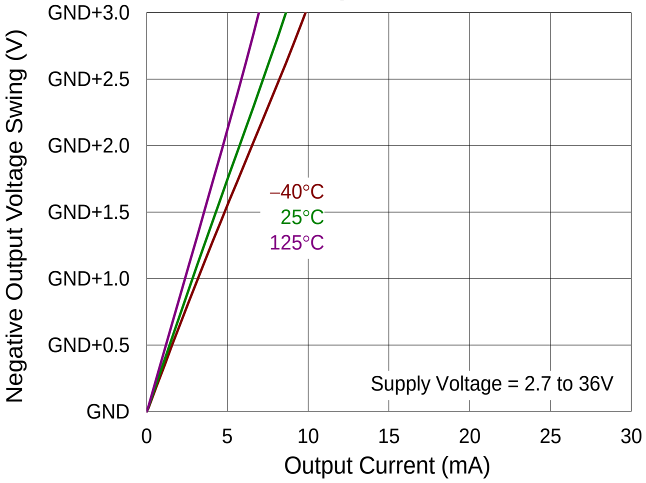
Common-Mode Rejection Ratio (CMRR) vs. Frequency



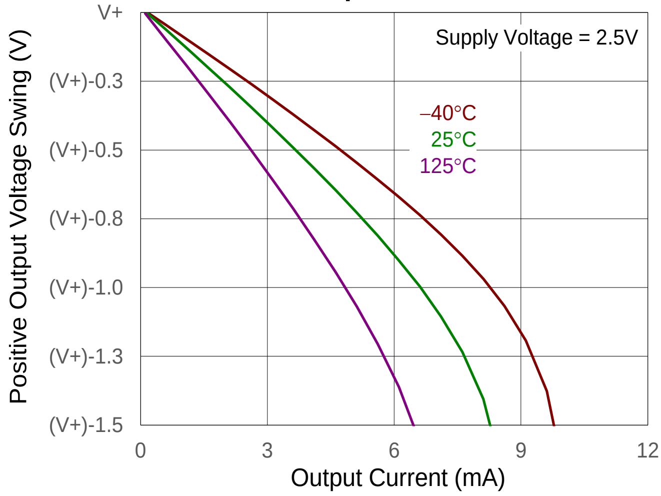
Positive Output Voltage Swing vs. Output Current



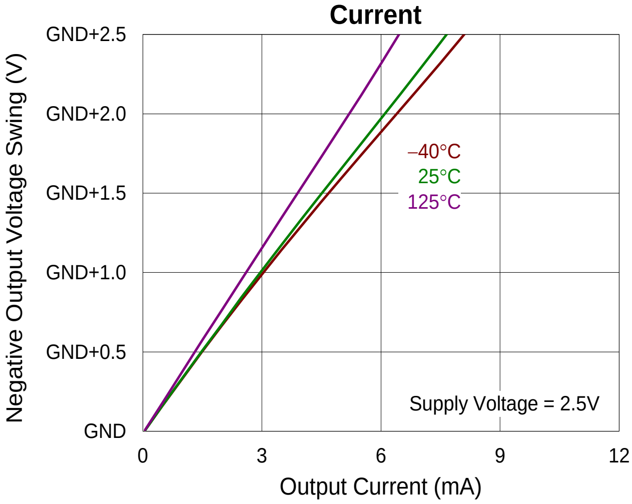
Negative Output Voltage Swing vs. Output Current



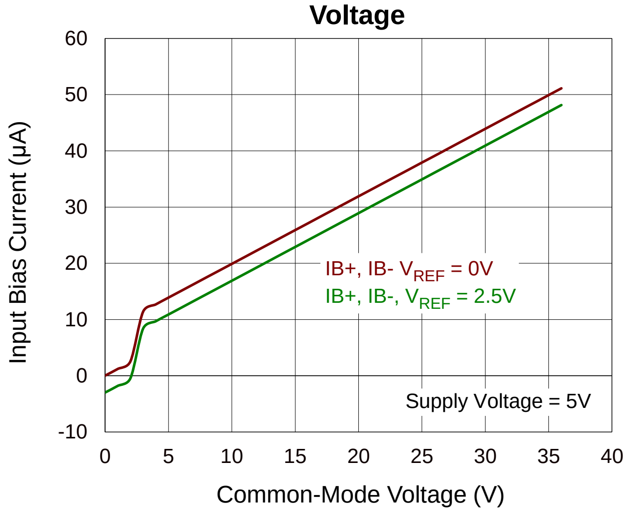
Positive Output Voltage Swing vs. Output Current



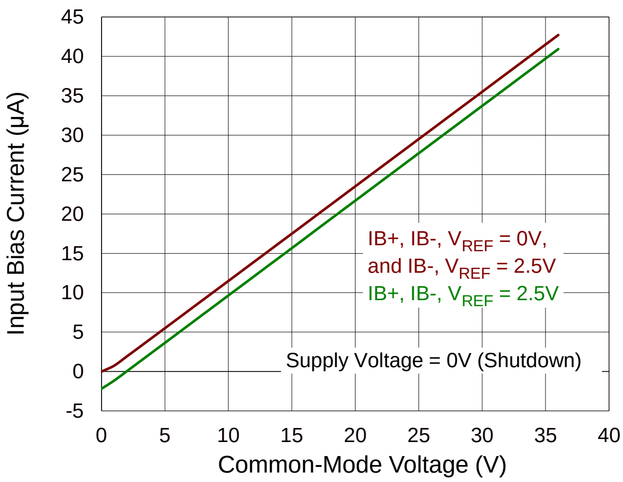
Negative Output Voltage Swing vs. Output Current



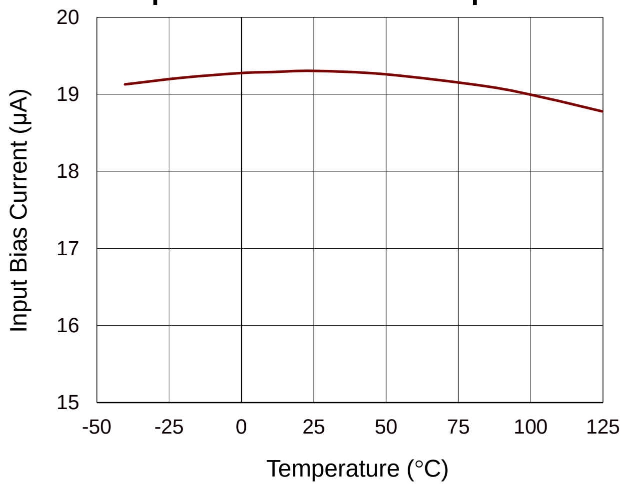
Input Bias Current vs. Common-Mode Voltage



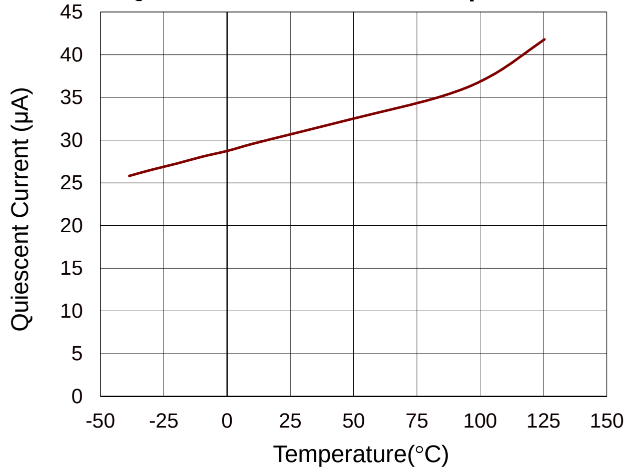
Input Bias Current vs. Common-Mode Voltage



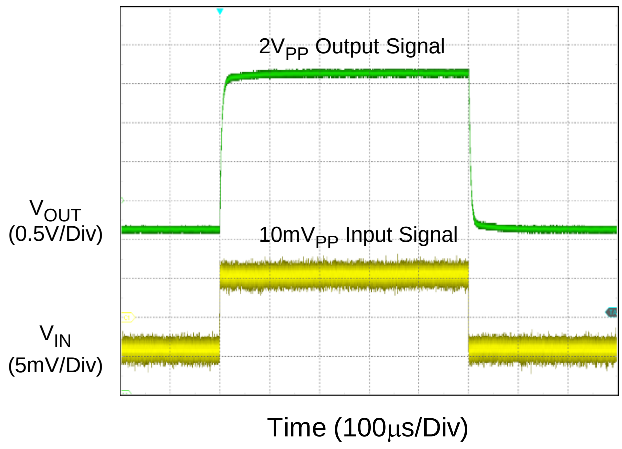
Input Bias Current vs. Temperature



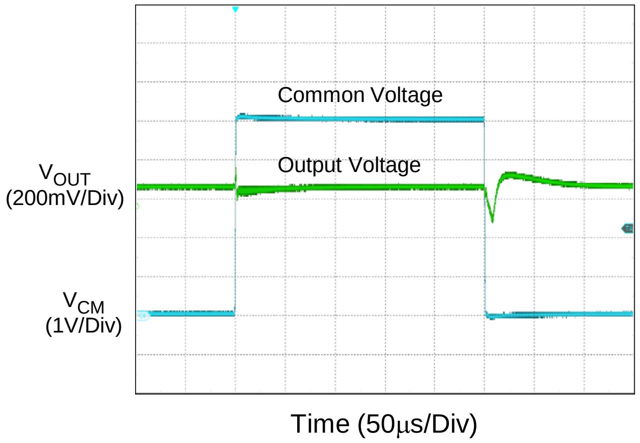
Quiescent Current vs. Temperature



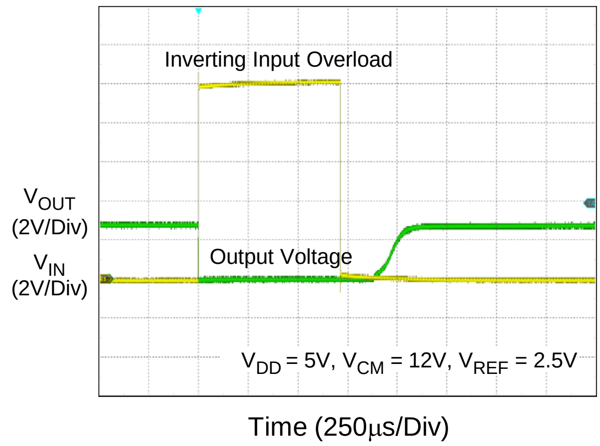
Step Response



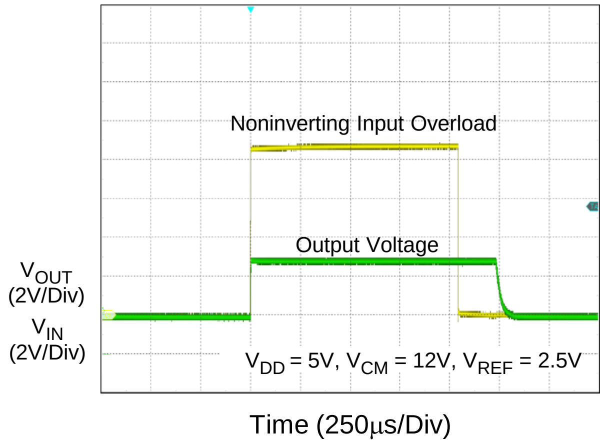
Common-Mode Voltage Transient Response



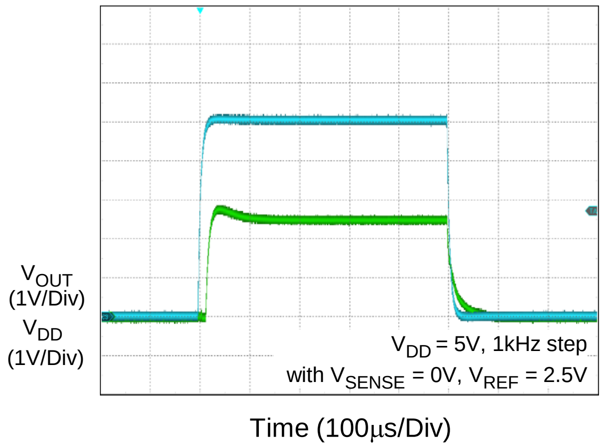
Inverting Differential Input Overload



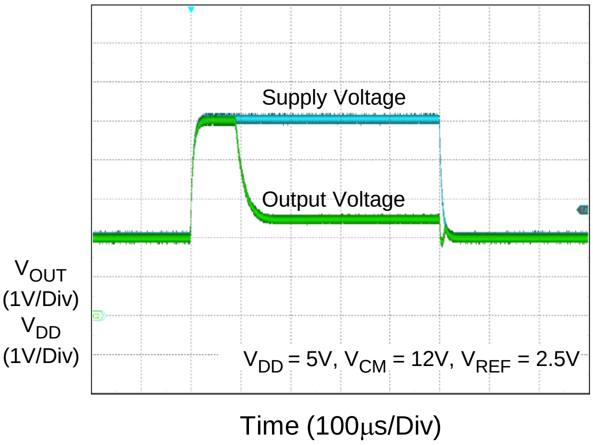
Noninverting Differential Input Overload



Start-Up Response



Brownout Recovery



16 Operation

The RTQ6060 series current-sense amplifiers are capable of being set up for both low-side and high-side current sensing applications. Low-side sensing is often favored for its simplicity, cost-effectiveness, and straightforward implementation using a basic operational amplifier circuit. However, the RTQ6060 devices offer the comprehensive differential input required for precise shunt connections and feature an integrated gain network that achieves a level of precision challenging to replicate with external resistors. While low-side sensing may be necessary for certain applications, only high-side sensing can detect shorts from the positive supply line to ground. Additionally, high-side sensing does not introduce extra resistance into the ground path of the load being monitored.

17 Application Information

([Note 11](#))

17.1 Sense Resistor Selection

The RTQ6060's zero-drift offset feature provides significant advantages, primarily allowing for reduced full-scale voltage drops across the shunt. Unlike traditional current shunt monitors that require a 100mV full-scale range for accurate operation, the RTQ6060 series achieves similar accuracy with a much smaller 10mV range. This efficiency in accuracy significantly reduces shunt dissipation and offers numerous other benefits.

Additionally, for applications that need to measure current across a wide dynamic range, the zero-drift offset at the lower end of the measurement spectrum is especially beneficial. In such cases, opting for a lower gain of 50 or 100 helps manage larger voltage drops at the higher end of the measurement scale.

17.2 Input Filtering Considerations

In some applications, the current being measured may be inherently noisy. In the case of a noisy signal, filtering after the output of the current sense amplifier is often simpler; however, this location negates the advantage of the low output impedance of the internal buffer.

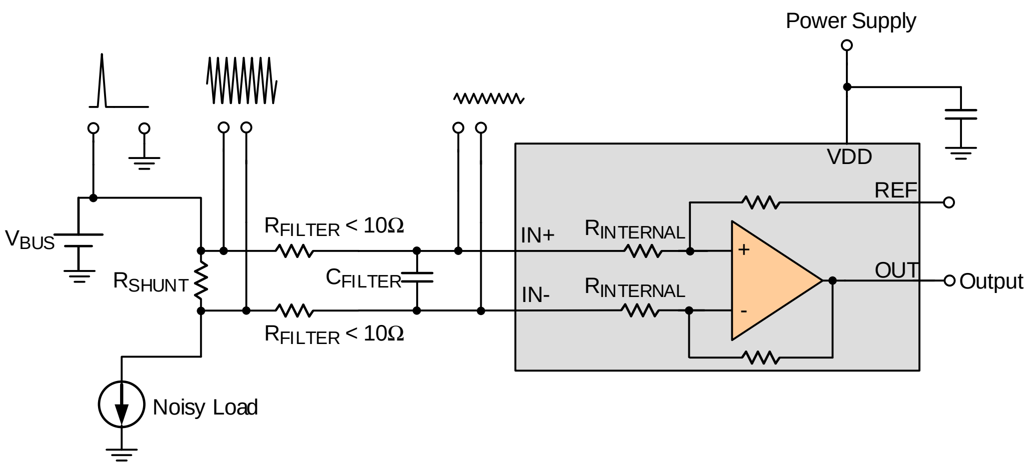


Figure 1. Input Filter

Incorporating external series resistors into the circuit introduces an additional source of measurement error, so it's crucial to limit the resistance value of these resistors to 10Ω or less, if feasible, to minimize any impact on measurement accuracy. The internal bias network, as depicted in [Figure 1](#) at the input pins, leads to a disparity in input bias currents when a differential voltage is applied across these pins. The introduction of extra external series filter resistors exacerbates this discrepancy, causing uneven voltage drops across the resistors and, consequently, a differential error voltage that detracts from the voltage across the shunt resistor. This discrepancy results in a voltage at the device input pins that differs from the voltage across the shunt resistor. In the absence of the added series resistance, the variance in input bias currents has a negligible impact on the device's functionality. The magnitude of error introduced by these external filter resistors can be determined using Equation 2, where the gain error factor is derived from Equation 1.

The variation in the differential voltage at the device input relative to the voltage at the shunt resistor is influenced by both the value of the external series resistors and the internal input resistors, $R_{INTERNAL}$ as indicated in [Figure 1](#). The attenuation of the shunt voltage that reaches the device input pins manifests as a gain error when the output voltage is compared to the voltage across the shunt resistor. A calculation can be performed to ascertain the extent of gain error introduced by the inclusion of external series resistance. The formula to compute the expected discrepancy from the shunt voltage to the voltage observed at the device input pins is provided in Equation 1.

$$\text{Gain Error Factor} = \frac{(1250 \times R_{INTERNAL})}{(1250 \times R_{FILTER}) + (1250 \times R_{INTERNAL}) + (R_{FILTER} + R_{INTERNAL})} \qquad (1)$$

The adjustment factor equation incorporates the device's internal input resistance, and this factor varies according to each gain version, as detailed in Table 1. The gain error factor for each specific device is listed in Table 2.

Table 1. Input Resistance

Product	Gain	$R_{INTERNAL}$ (kΩ)
RTQ6060-50	50	20
RTQ6060-75	75	13.3
RTQ6060-100	100	10
RTQ6060-200	200	5
RTQ6060-500	500	2
RTQ6060-1000	1000	1

Table 2. Device Gain Error Factor

Product	Simplified Gain Error Factor
RTQ6060-50	$\frac{20,000}{(17 \times R_{FILTER}) + 20,000}$
RTQ6060-75	$\frac{8,000}{(7 \times R_{FILTER}) + 8,000}$
RTQ6060-100	$\frac{10,000}{(9 \times R_{FILTER}) + 10,000}$
RTQ6060-200	$\frac{1,000}{R_{FILTER} + 1,000}$
RTQ6060-500	$\frac{10,000}{(13 \times R_{FILTER}) + 10,000}$
RTQ6060-1000	$\frac{5,000}{(9 \times R_{FILTER}) + 5,000}$

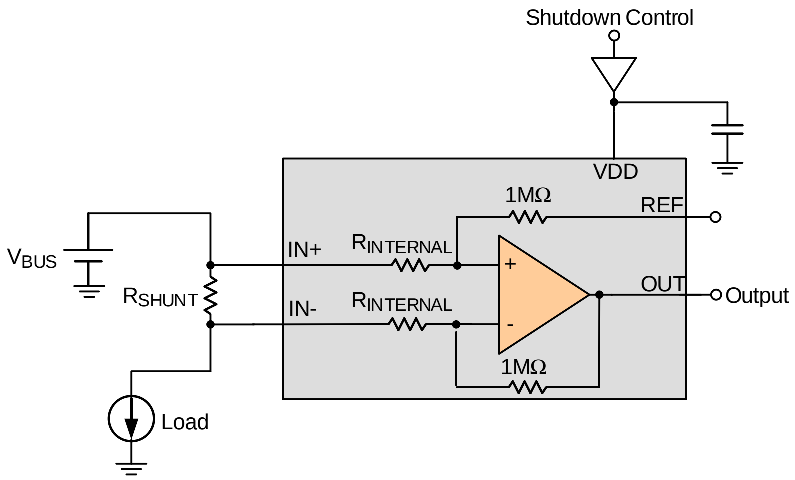
Thus, the expected gain error resulting from the inclusion of external series resistors can be determined using Equation 2.

$$\text{Gain Error (\%)} = 100 - (100 \times \text{Gain Error Factor}) \qquad (2)$$

17.3 Shutdown Procedure

Fundamentally, the RTQ6060 series lacks a built-in shutdown feature, yet its low power consumption allows for control via an external logic gate or transistor switch. This external component can efficiently toggle the RTQ6060's standby power on or off as required.

In scenarios where current is monitored through a shunt resistor, a critical aspect during shutdown is the potential residual current that continues to flow from the shunt circuit. This can be analyzed by examining a simplified diagram of the RTQ6060 in its unpowered state, as illustrated in Figure 2.



PRODUCT	$R_{INTERNAL}$
RTQ6060-50	20kΩ
RTQ6060-75	13.3kΩ
RTQ6060-100	10kΩ
RTQ6060-200	5kΩ
RTQ6060-500	2kΩ
RTQ6060-1000	1kΩ

Figure 2. Fundamental Setup for Disabling the RTQ6060 Using a Grounded Reference Point

The impedance from each input of the RTQ6060 to its output and reference pins is generally slightly more than 1 megaohm (MΩ), a result of combining 1MΩ feedback and 5kΩ input resistors. The current flow through these pins depends on their specific connections. For instance, if the reference pin is grounded, calculating the effect of the 1MΩ impedance from the shunt to ground is straightforward.

Conversely, if the reference or operational amplifier remains active while the RTQ6060 is deactivated, the impedance should be considered as 1MΩ to the reference voltage, rather than to ground. If the reference or operational amplifier is also deactivated, it becomes essential to understand their output impedance in the shutdown state for precise calculations.

Regarding the path from the inputs to the output pin, when the RTQ6060 is disabled, this pathway effectively acts as a solid ground connection. Consequently, any current flowing through this route is directly proportional to the common-mode voltage applied across the shunt resistor to the 1MΩ resistor.

17.4 Effects of REF Input Impedance

The common-mode rejection ratio (CMRR) of the RTQ6060 series, like that of any differential amplifier, is influenced by the impedance at the REF input. This is generally not an issue when the REF pin is directly connected to a reference or power supply. However, when a resistive divider is employed from the power supply or a reference voltage, buffering the REF pin with an operational amplifier is essential to ensure proper operation.

In setups where the output of the RTQ6060 is measured differentially, such as with a differential input analog-to-digital converter (ADC) or by using two separate ADC inputs, the influence of external impedance on the REF input can be effectively neutralized. Figure 3 illustrates a technique for deriving the output from the RTQ6060 by using the REF pin as a reference point.

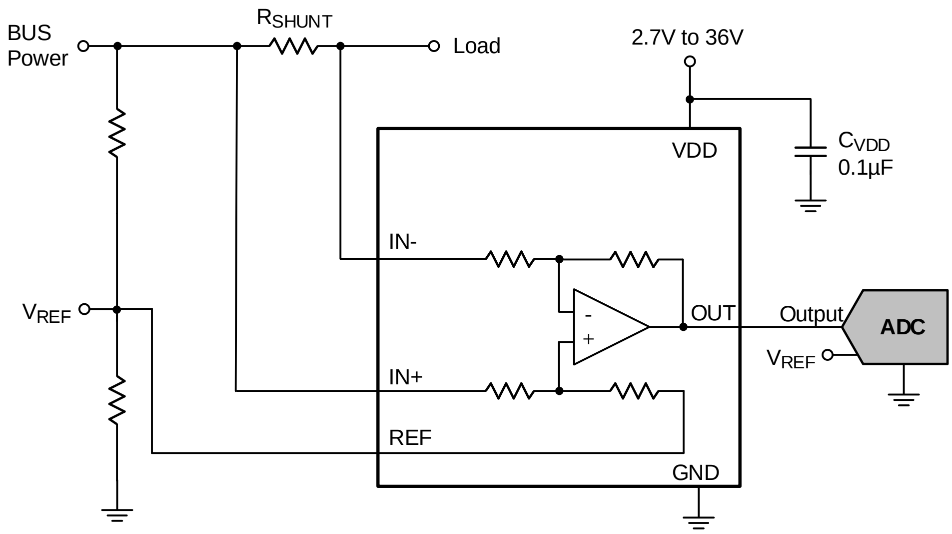


Figure 3. Utilizing the RTQ6060 to Neutralize the Impact of Impedance on the REF Input

17.5 Managing Common-Mode Transients Above 36 Volts

To accommodate transients exceeding 36V, such as those encountered in automotive environments, the RTQ6060 series can be integrated into circuits with minimal additional components. It is recommended to utilize Zener diodes or Zener-type transient voltage suppressors due to their rapid response; other transient suppressors with slower reaction times are not suitable. The initial step involves incorporating a pair of resistors to act as a working impedance for the Zener diode. It is generally best to use the smallest possible resistors, typically around 10Ω. While larger resistors can be employed, they may influence the gain as previously mentioned in the Input Filtering Considerations section. Since the circuit is designed to limit only short-duration transients, a 10Ω resistor in conjunction with standard Zener diodes of the lowest available power rating is often sufficient. This setup is advantageous as it occupies minimal space on the circuit board.

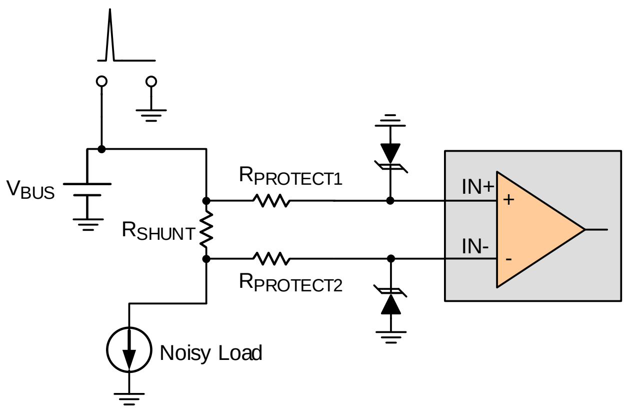


Figure 4. Dual TVS Transient Common-Mode Protection

If low-power Zener diodes are inadequate for sufficient transient protection, the need arises to use higher-power transient voltage suppressor diodes. The most compact solution then includes using a single transzorb and series-connected back-to-back diodes between the device inputs.

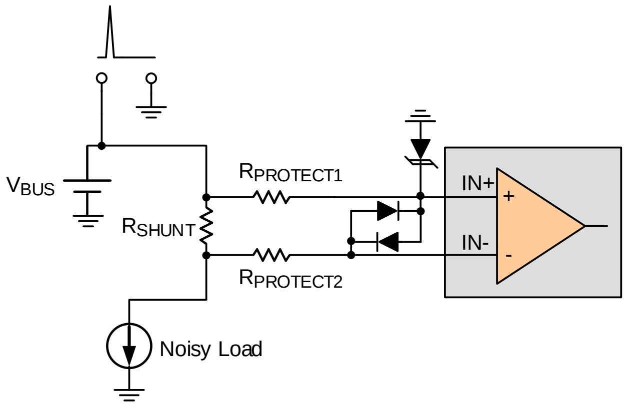


Figure 5. Single TVS Transient Common-Mode Protection

17.6 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 θ_{JA} is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is normally 125°C. The junction-to-ambient thermal resistance, θ_{JA}, is highly package dependent. For a SC-70-6 package, the thermal resistance, θ_{JA}, is 183.9°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 follows:

$P_{D(MAX)}$ = (125°C – 25°C) / (183.9°C/W) = 0.54W for a SC-70-6 package.

The maximum power dissipation depends on the operating ambient temperature for the fixed $T_{J(MAX)}$ and the thermal resistance, θ_{JA}. The derating curve in Figure 6 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

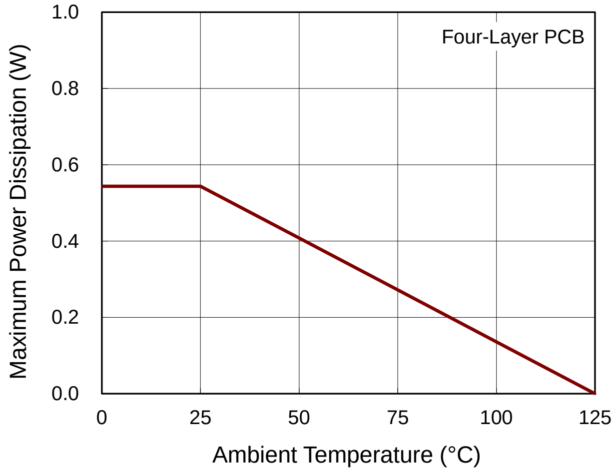


Figure 6. Derating Curve of Maximum Power Dissipation

17.7 Layout Guidelines

- A Kelvin sense arrangement is required for best performance. Connect the input pins (VIN+ and VIN-) to the sensing resistor using a 4-wire connection.
- PCB trace resistance from the sense resistor to the VIN+ and VIN- pins can affect the power measurement accuracy. Place the sense resistors as close as possible to the RTQ6060 and do not use minimum width PCB traces.
- Place the power-supply bypass capacitor 0.1μF as close as possible to the supply and ground pins.

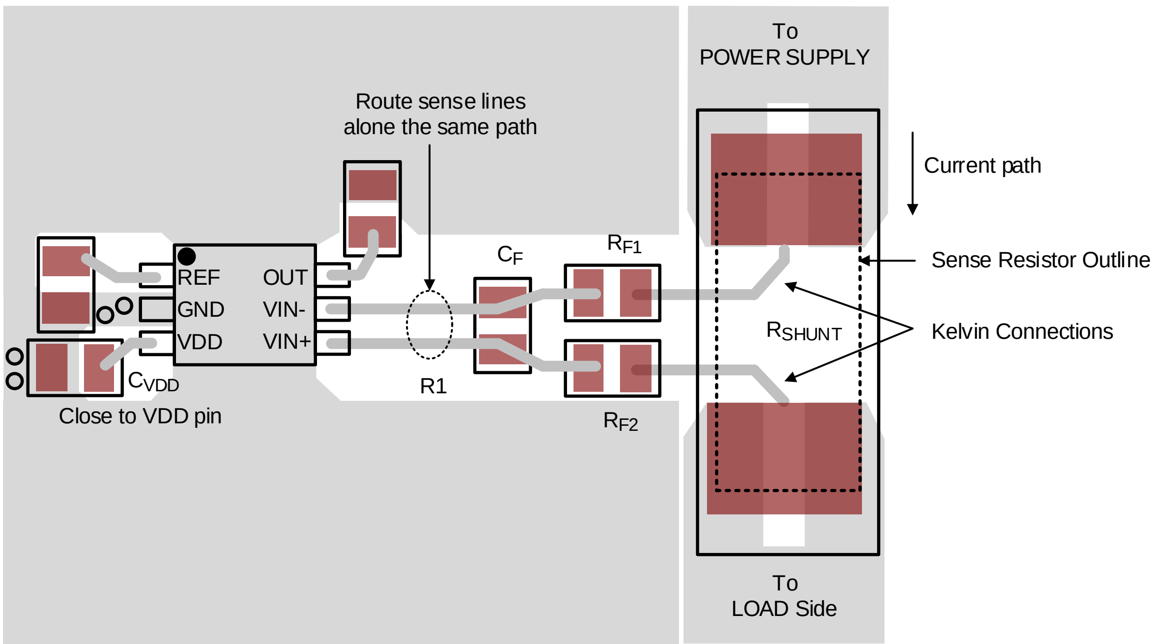
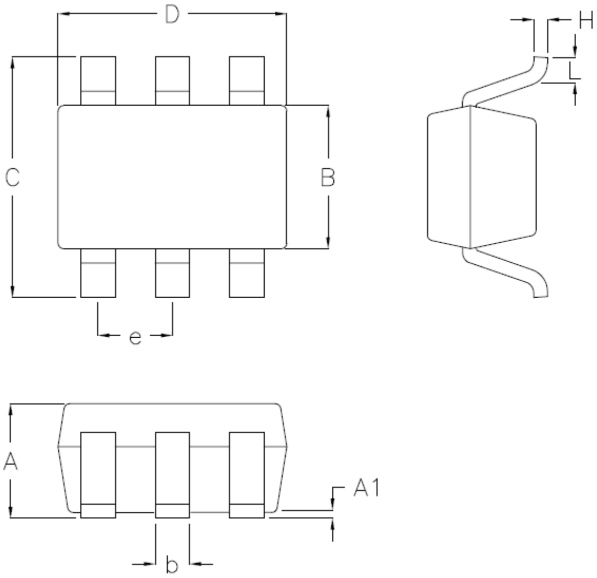


Figure 7. Layout Guideline

Note 11. The information provided in this section is for reference only. The customer is solely responsible for designing, validating, and testing any applications incorporating Richtek's product(s). The customer is also responsible for applicable standards and any safety, security, or other requirements.

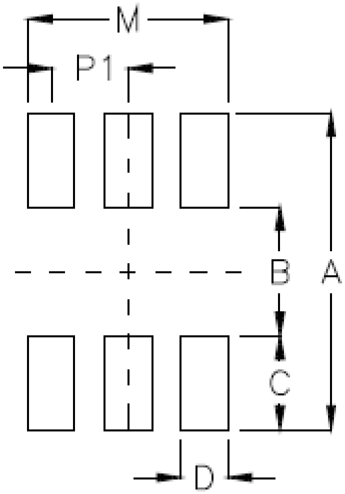
18 Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
A	0.800	1.100	0.031	0.044
A1	0.000	0.100	0.000	0.004
B	1.150	1.350	0.045	0.054
b	0.150	0.400	0.006	0.016
C	1.800	2.400	0.071	0.094
D	1.800	2.200	0.071	0.087
e	0.650		0.026	
H	0.080	0.260	0.003	0.010
L	0.210	0.460	0.008	0.018

SC-70-6 Surface Mount Package

19 Footprint Information

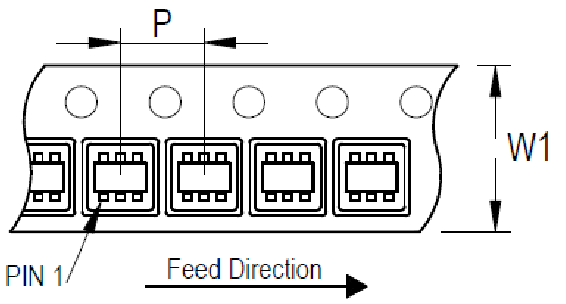


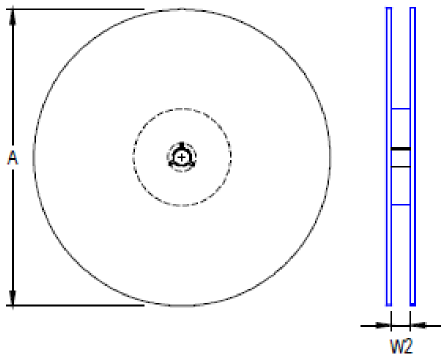
Package	Number of Pin	Footprint Dimension (mm)						Tolerance
		P1	A	B	C	D	M	
SC-70-6	6	0.65	2.70	1.10	0.80	0.40	1.70	±0.10

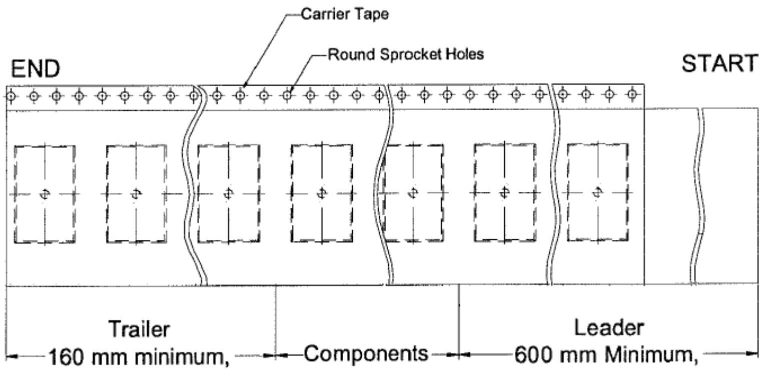
20 Packing Information

20.1 Tape and Reel Data

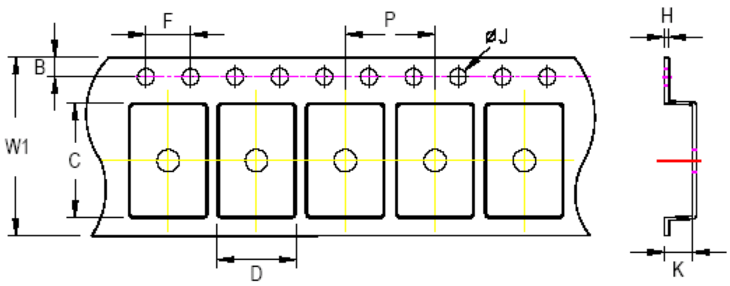
SC-70-4/6/8:







Package Type	Tape Size (W1) (mm)	Pocket Pitch (P) (mm)	Reel Size (A)		Units per Reel	Trailer (mm)	Leader (mm)	Reel Width (W2) Min/Max (mm)
			(mm)	(in)				
SC-70-6	8	4	180	7	3,000	160	600	8.4/9.9



C, D, and K are determined by component size. The clearance between the components and the cavity is as follows:

- For 8mm carrier tape: 0.5mm max.

Tape Size	W1	P		B		F		ØJ		K		H
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max
8mm	8.3mm	3.9mm	4.1mm	1.65mm	1.85mm	3.9mm	4.1mm	1.5mm	1.6mm	1.0mm	1.3mm	0.6mm

20.2 Tape and Reel Packing

Step	Photo/Description	Step	Photo/Description
1	 Reel 7”	4	 3 reels per inner box **Box A**
2	 HIC & Desiccant (1 Unit) inside	5	 12 inner boxes per outer box
3	 Caution label is on backside of Al bag	6	 Outer box **Carton A**

Container / Package	Reel		Box			Carton		
	Size	Units	Item	Reels	Units	Item	Boxes	Unit
SC-70-6	7”	3,000	Box A	3	9,000	Carton A	12	108,000
			Box E	1	3,000	For Combined or Partial Reel.		

20.3 Packing Material Anti-ESD Property

Surface Resistance	Aluminum Bag	Reel	Cover tape	Carrier tape	Tube	Protection Band
Ω/cm^2	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**

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21 Datasheet Revision History

Version	Date	Description	Item
00	2024/11/12	First Edition	*ESD Ratings on page 6* - Updated CDM value