

36V, 1.3MHz, Zero-Drift, Voltage-Output, Current Monitor

1 General Description

The RTQ6080 is a high-precision current sense amplifier widely used in most current-reporting systems and current-sensing circuits for precision-current measurement and system optimization. The device can sense a low-voltage drop across the shunt resistor over a wide common-mode voltage range from 3V to 36V. They feature extremely low input offset, offset drift, gain error, and gain drift, all achieved through a zero-drift architecture. Five fixed gains options – 20, 50, 100, 200, and 500V/V – are available to accommodate different current scaling applications. The RTQ6080 is designed not only for DC current measurement but also for high-speed transient applications such as fast overcurrent protection, with a high bandwidth of 1.3MHz and a 65dB AC CMRR at 50kHz.

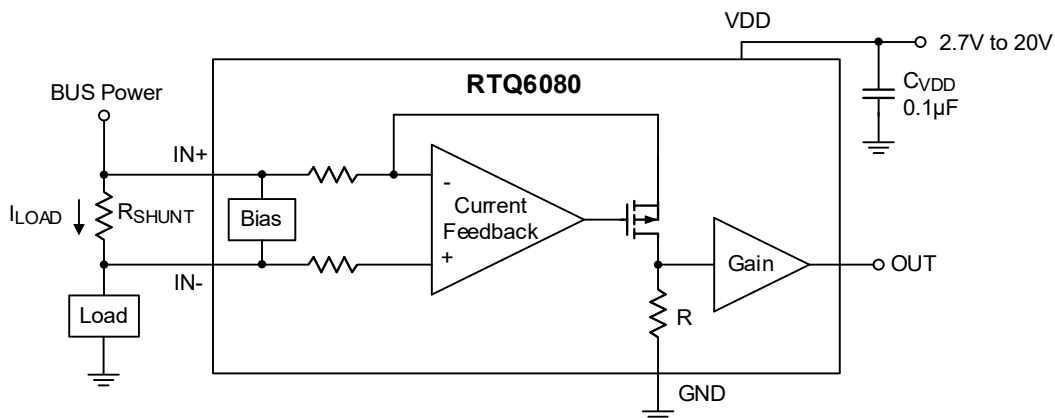
The device operates from a single power supply ranging from 2.7V to 20V and draw 1.2mA of supply current. The RTQ6080 is available in an SOT-23-5 package with two pinout variants.

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

2 Features

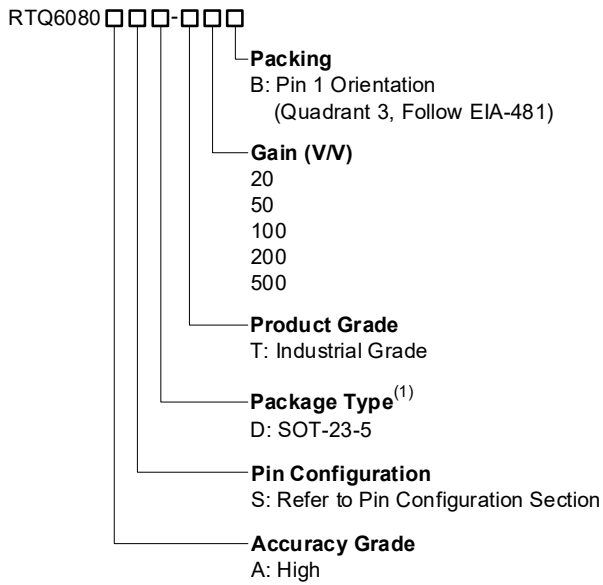
- **Wide Common-Mode Range: 3V to 36V**
- **High-Side Sensing**
- **High Bandwidth: 1.3MHz**
- **Accuracy**
 - **Gain Error**
 - **RTQ6080A: ±0.5% (Maximum)**
 - **20ppm/°C Gain Drift (Maximum)**
 - **Offset**
 - **RTQ6080A: ±120µV (Maximum)**
 - **RTQ6080A: 1µV/°C Offset Drift (Maximum)**
- **Common-Mode Rejection Ratio (CMRR)**
 - **100dB DC CMRR**
 - **65dB AC CMRR (f = 50kHz)**
- **Choice of Gains**
 - **RTQ6080-20: 20V/V**
 - **RTQ6080-50: 50V/V**
 - **RTQ6080-100: 100V/V**
 - **RTQ6080-200: 200V/V**
 - **RTQ6080-500: 500V/V**
- **Slew Rate: 9V/µs**
- **Package: 5-Pin SOT-23**

3 Simplified Application Circuit



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

4 Ordering Information



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

- Power Management Devices
- Overcurrent Detection Systems
- Battery Monitoring Units
- Solar Inverter Units
- Lighting Control Technologies
- Network Equipment

6 Marking Information

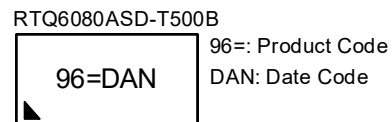
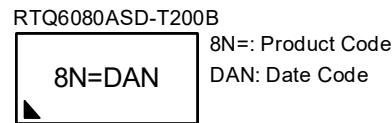
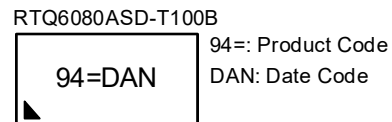
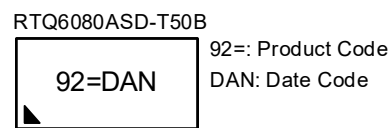
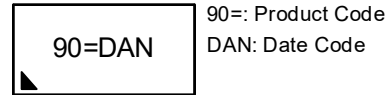
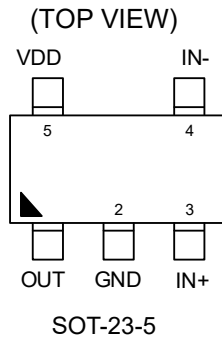


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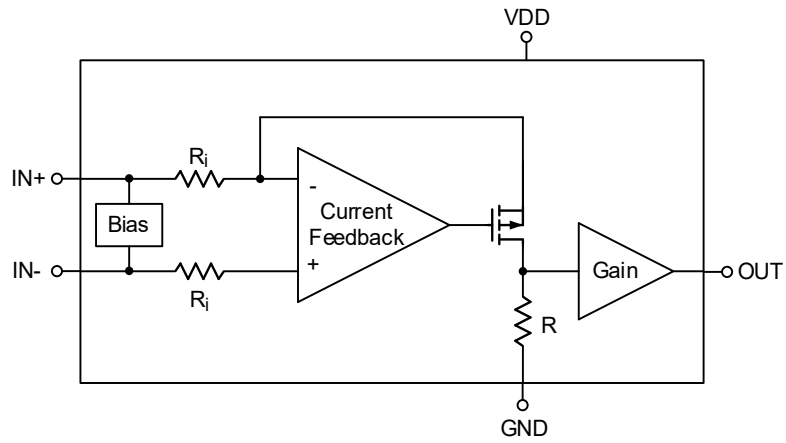
7 Pin Configuration



8 Functional Pin Description

Pin No.	Pin Name	I/O	Pin Function
1	OUT	Analog Output	Voltage output. V_{OUT} is proportional to V_{SENSE} ($IN+ - IN-$).
2	GND	Analog Ground	Power ground.
3	IN+	Analog Input	Shunt voltage positive input. Connect this pin to supply side of shunt resistor.
4	IN-	Analog Input	Shunt voltage negative input. Connect this pin to load side of shunt resistor.
5	VDD	Power Input	Power supply. The input voltage range is from 2.7V to 20V. Connect an input capacitor of 0.1 μ F, X7R or larger ceramic capacitor between this pin and GND.

9 Functional Block Diagram



10 Absolute Maximum Ratings

(Note 2 and Note 3)

- Supply Input Voltage, V_{DD} ----- -0.3V to 22V
- Common-Mode Voltage, V_{IN+} ----- -0.3V to 39.6V
- Common-Mode Voltage, V_{IN-} ----- -0.3V to 39.6V
- Differential Shunt Voltage, $(V_{IN+}) - (V_{IN-})$ ----- -4V to 4V
- Output Voltage, V_{OUT} ----- -0.3V to $(V_{DD} + 0.3V)$
- Lead Temperature (Soldering, 10 sec.)----- 260°C
- Junction Temperature ----- 150°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.

11 ESD Ratings

(Note 4)

- ESD Susceptibility
 - HBM (Human Body Model)----- 2kV
 - CDM (Charged Device Model) ----- 500V

Note 4. Devices are ESD sensitive. Handling precautions are recommended.

12 Recommended Operating Conditions

(Note 5)

- Supply Input Voltage, V_{DD} ----- 20V
- Common-Mode Voltage, V_{IN+} , V_{IN-} ----- 36V
- Ambient Temperature Range----- -40°C to 125°C

Note 5. The device is not guaranteed to function outside its operating conditions.

13 Thermal Information

(Note 6)

Thermal Parameter		SOT-23-5	Unit
θ_{JA}	Junction-to-ambient thermal resistance (JEDEC standard)	192.7	°C/W
$\theta_{JC(Top)}$	Junction-to-case (top) thermal resistance	100	°C/W
$\theta_{JC(Bottom)}$	Junction-to-case (bottom) thermal resistance	69.6	°C/W

Note 6. θ_{JA} is simulated under natural convection (still air) at $T_A = 25^\circ\text{C}$ with the component mounted on a high effective-thermal-conductivity two-layer test board on a JEDEC 51-7 thermal measurement standard. θ_{JC} is simulated at the bottom of the package.

14 Electrical Characteristics

($T_A = 25^\circ\text{C}$, $V_{DD} = 5\text{V}$, $V_{SENSE} = V_{IN+} - V_{IN-} = 0.5\text{V} / \text{Gain}$, and $V_{CM} = V_{IN-} = 12\text{V}$, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supply						
Operating Supply Range	V_{DD}	$T_A = -40^\circ\text{C}$ to 125°C	2.7	--	20	V
Quiescent Current	I_Q		--	0.6	1.2	mA
		$T_A = -40^\circ\text{C}$ to 125°C	--	--	1.4	mA
Input						
Common-Mode Input Range (Note 7)	V_{CM}	$T_A = -40^\circ\text{C}$ to 125°C	3	--	36	V
Common-Mode Rejection	CMRR	$T_A = -40^\circ\text{C}$ to 125°C $V_{CM} = 3\text{V}$ to 36V	100	120	--	dB
		$f = 50\text{kHz}$	--	65	--	
Offset Voltage, RTI (Note 8)	V_{OS}		--	± 25	± 120	μV
Offset Voltage, RTI vs. Temperature		$T_A = -40^\circ\text{C}$ to 125°C	--	± 0.1	± 1	$\mu\text{V}/^\circ\text{C}$
Power Supply Ripple Rejection, RTI	PSRR	$V_{DD} = 2.7\text{V}$ to 20V $T_A = -40^\circ\text{C}$ to 125°C	--	± 5	± 30	$\mu\text{V}/\text{V}$
Input Bias Current	I_{B+}	$V_{SENSE} = 0\text{mV}$	50	100	150	μA
	I_{B-}	$V_{SENSE} = 0\text{mV}$	50	100	150	
Output						
Gain	A_V	RTQ6080-20	--	20	--	V/V
		RTQ6080-50	--	50	--	
		RTQ6080-100	--	100	--	
		RTQ6080-200	--	200	--	
		RTQ6080-500	--	500	--	
Gain Error	A_{V_ERROR}	$50\text{mV} \leq V_{OUT} \leq V_{DD} - 200\text{mV}$	--	± 0.04	± 0.5	%
Gain Error vs. Temperature		$T_A = -40^\circ\text{C}$ to 125°C	--	± 2	± 20	ppm/ $^\circ\text{C}$
Nonlinearity Error			--	± 0.01	--	%
Maximum Capacitive Load		No sustained oscillation	--	330	--	pF
Swing to VDD Power-Supply Rail		$T_A = -40^\circ\text{C}$ to 125°C $R_L = 10\text{k}\Omega$ to GND	--	$V_{DD} - 0.07$	$V_{DD} - 0.15$	V
Swing to GND		$T_A = -40^\circ\text{C}$ to 125°C $R_L = 10\text{k}\Omega$ to GND, $V_{SENSE} = 0\text{mV}$	--	$\text{GND} + 0.005$	$\text{GND} + 0.02$	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Frequency Response						
Bandwidth (Note 9)	BW	CLOAD = 5pF RTQ6080-20 VSENSE = 200mV	--	1300	--	kHz
		CLOAD = 5pF RTQ6080-50 VSENSE = 80mV	--	1300	--	
		CLOAD = 5pF RTQ6080-100 VSENSE = 40mV	--	1000	--	
		CLOAD = 5pF RTQ6080-200 VSENSE = 20mV	--	900	--	
		CLOAD = 5pF RTQ6080-500 VSENSE = 8mV	--	900	--	
Slew Rate	SR		--	9	--	V/μs
Settling Time		VOUT = 4V±0.1V step, output settles to 0.5%	--	24	--	μs
		VOUT = 4V±0.1V step, output settles to 1%	--	14	--	
		VOUT = 4V±0.1V step, output settles to 5%	--	7	--	
Voltage Noise Density (Note 9)			--	50	--	nV/√Hz

Note 7. V_{CM} is the common mode voltage, which includes both V_{IN+} and V_{IN-}.

Note 8. RTI = Referred-to-Input.

Note 9. Guaranteed by design.

15 Typical Application Circuit

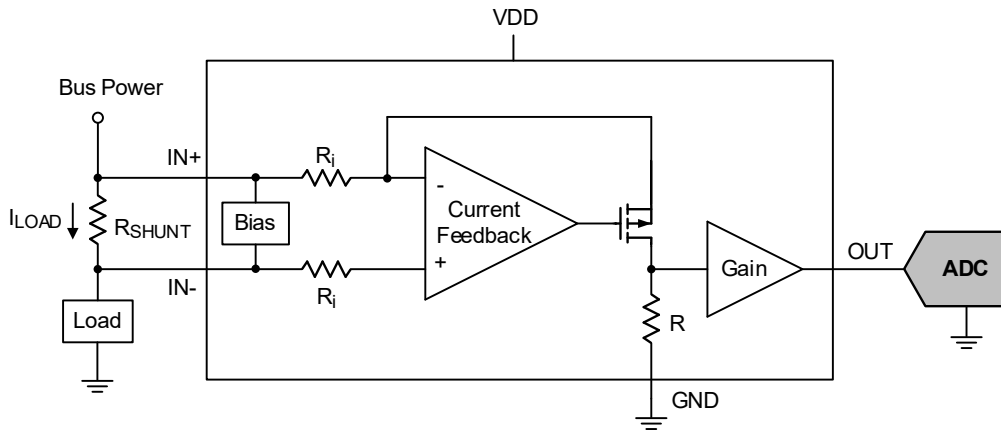
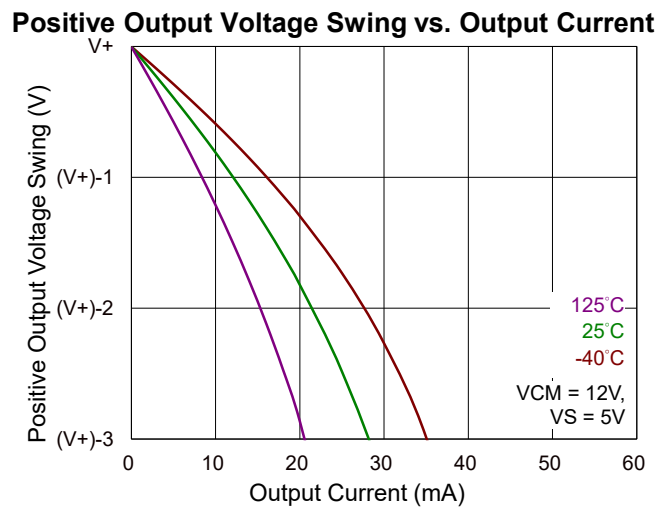
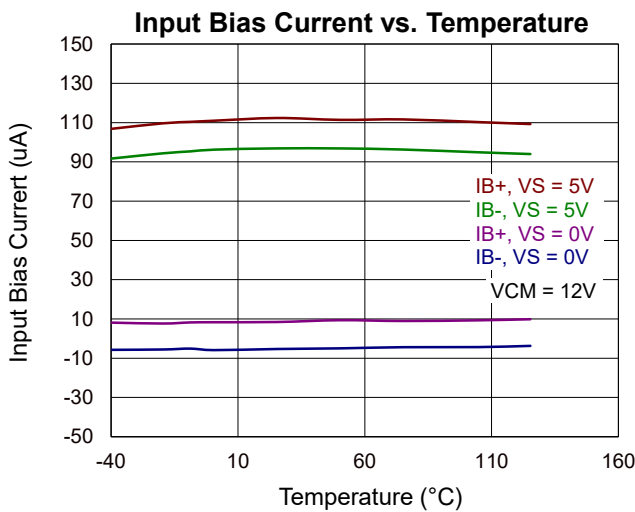
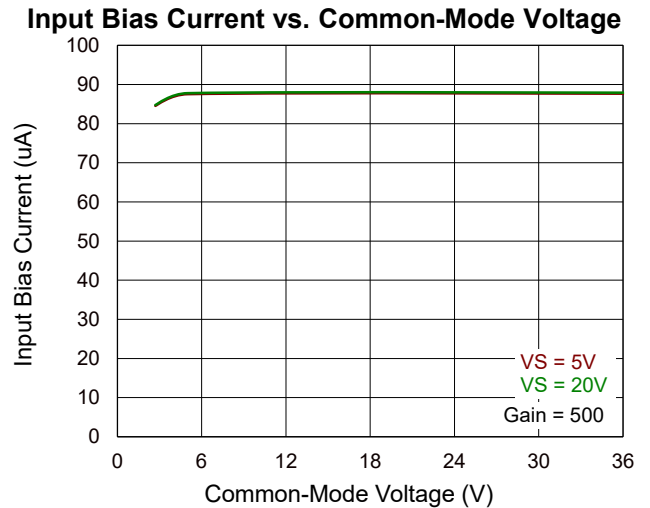
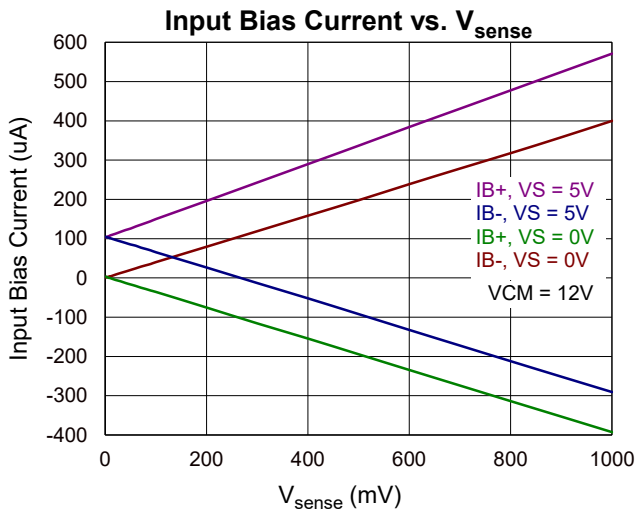
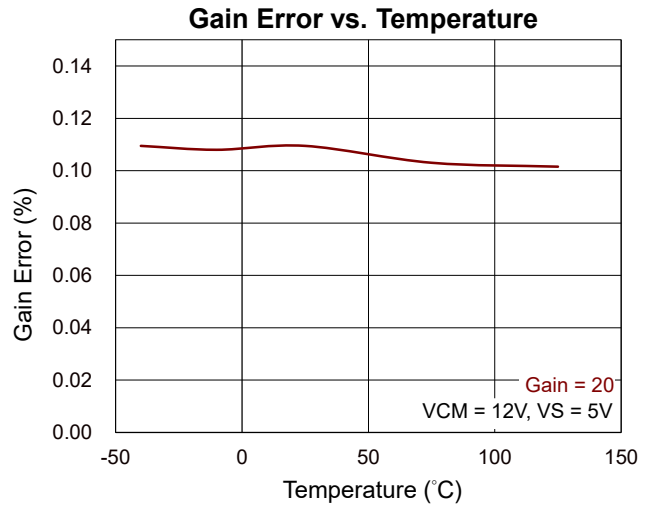
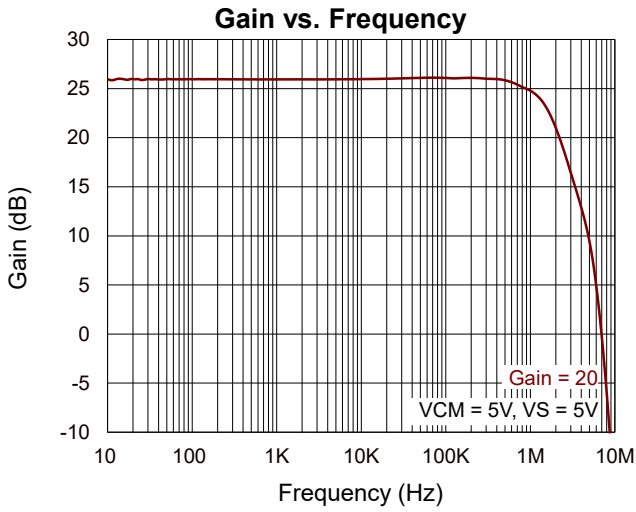
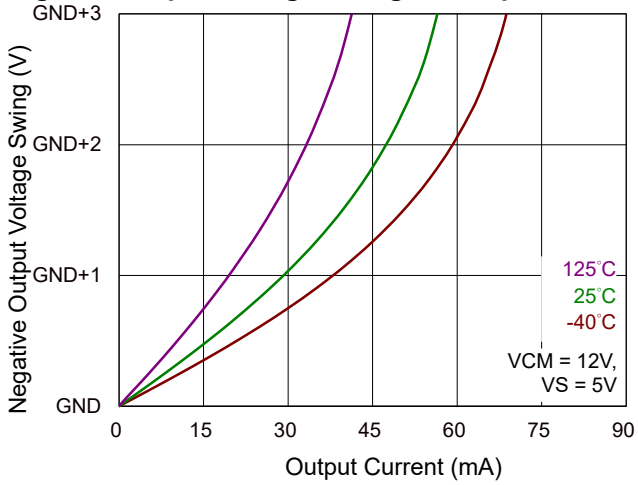


Figure 1. Unidirectional Configuration

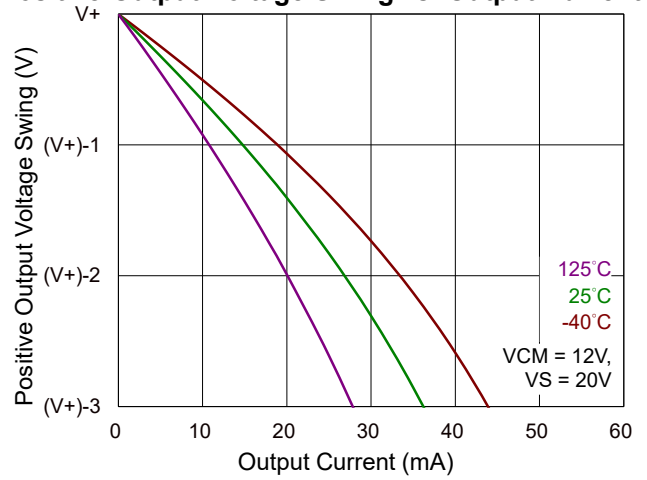
16 Typical Operating Characteristics



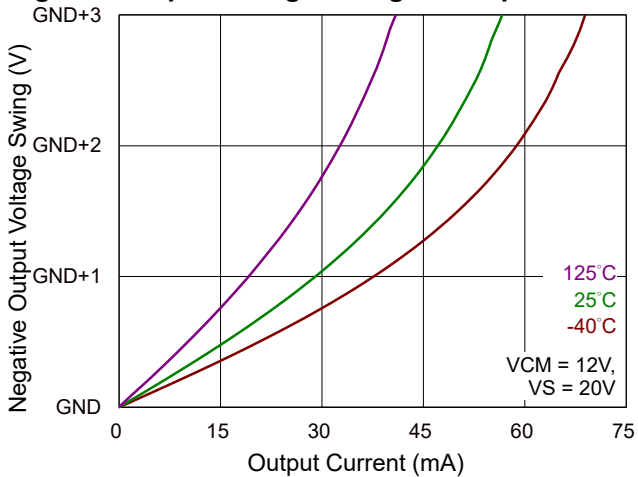
Negative Output Voltage Swing vs. Output Current



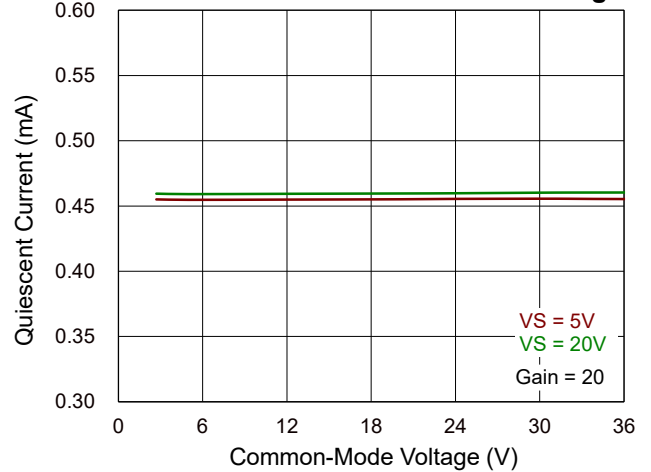
Positive Output Voltage Swing vs. Output Current



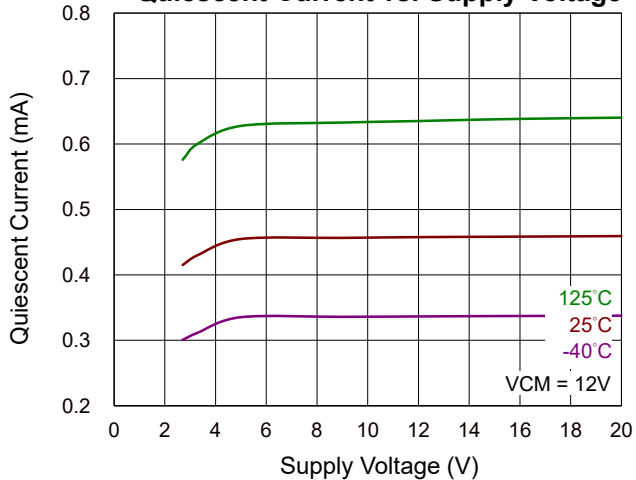
Negative Output Voltage Swing vs. Output Current



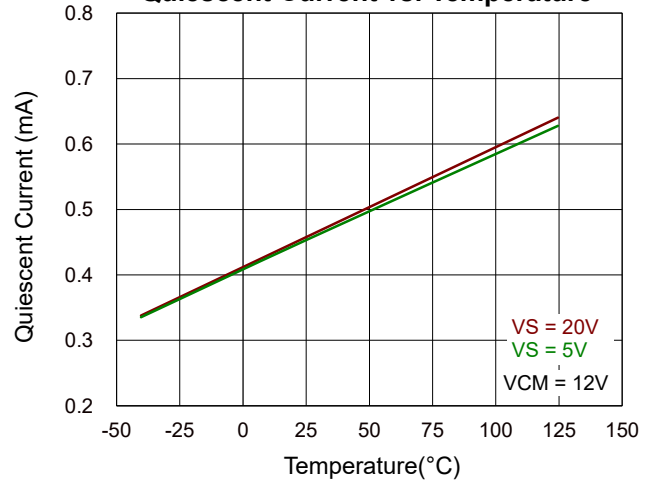
Quiescent Current vs. Common-Mode Voltage



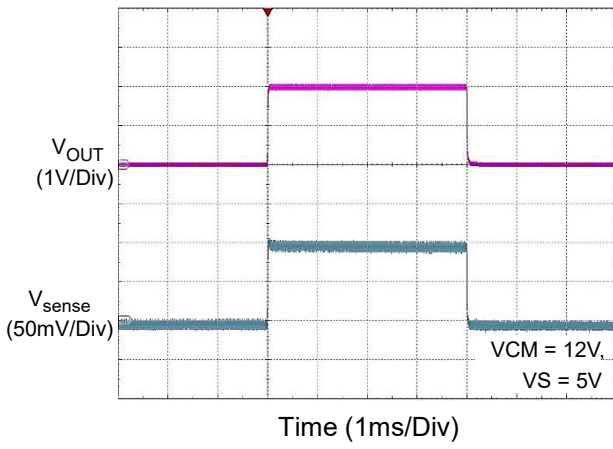
Quiescent Current vs. Supply Voltage



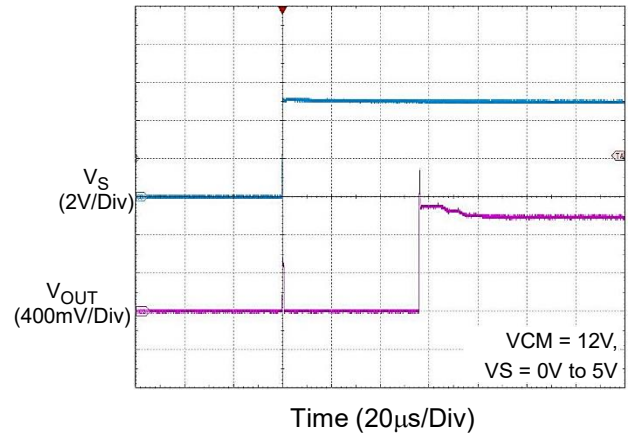
Quiescent Current vs. Temperature



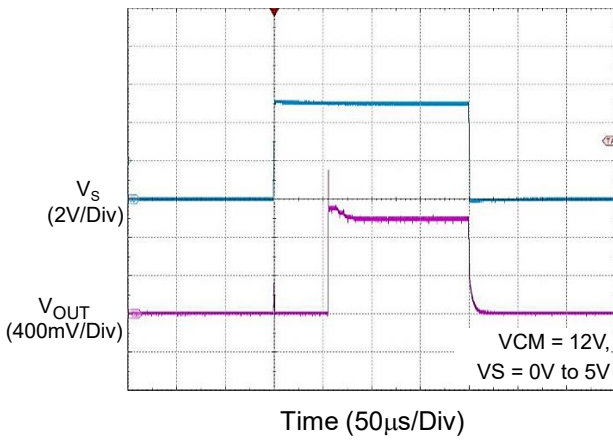
Step Response



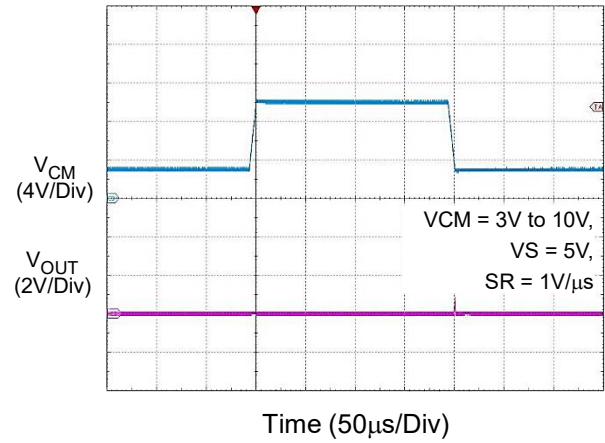
VS Power On



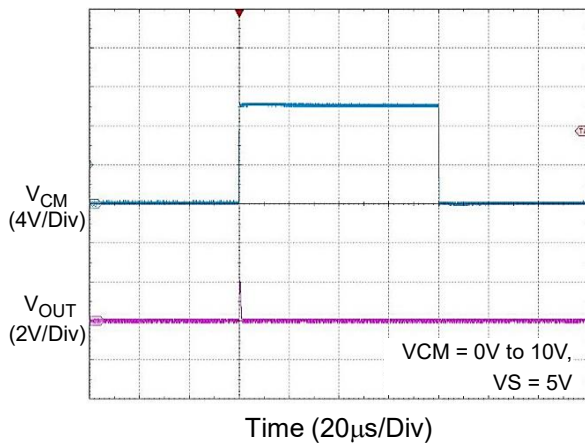
VS Transient Response



VCM Transient Response



VCM Transient Response



17 Operation

17.1 Gain Error and Input Offset Voltage

A two-step method is used to characterize gain error and offset voltage. First, the gain is determined by measuring the output voltage at different sense voltages.

$$GAIN = \frac{(V_{DD} - 200mV) - 50mV}{V_{sense1} - V_{sense2}}$$

where

VSENSE1 = SENSE voltage with VOUT = (V_{DD} - 200mV)

VSENSE2 = SENSE voltage with VOUT = 50 mV

The input offset voltage is then measured at VSENSE = 0mV and is referred to the input (RTI) of the current shunt monitor, as specified in the Electrical Characteristics section:

Current-Shunt Monitor. VRTI (Referred-To-Input) = $\frac{V_{OUT}}{GAIN}$

17.2 Temperature Error of Gain

As temperature increases or decreases, the gain error will vary. The maximum error can be estimated using the following formula:

$$GAIN = Gain\ Error\% + \left(\frac{Gain\ Error\ drift}{10000} \times \Delta T \right)\%$$

Example:

Temperature: 125°C

Maximum gain error: 0.5%

Maximum gain error vs. temperature drift: 20ppm/°C ($\frac{20}{10000} \%ppm/°C$)

$$GAIN = Gain\ Error\% + \left(\frac{Gain\ Error\ drift}{10000} \times \Delta T \right)\% = 0.5\% + \left(\frac{20}{10000} \times (125-25)°C \right)\% = 0.7\%$$

18 Application Information

(Note 10)

The RTQ6080 is a high-precision current-sense amplifier with a wide common-mode input range from 3V to 36V, excellent common-mode rejection ratio (CMRR), high bandwidth, and fast slew rate. The devices are available with five output voltage scales: 20V/V, 50V/V, 100V/V, 200V/V, and 500V/V, users can select the appropriate gain version based on different application scenarios.

18.1 Shunt Resistor Selection

The value selected for the shunt resistor, R_{SHUNT} , depends on the application and represents a compromise between small-signal accuracy and the maximum permissible voltage drop in the measurement line. High values of R_{SHUNT} provide better accuracy at lower currents by minimizing the effects of offset, while lower values of R_{SHUNT} minimize voltage loss in the supply line. The maximum value of R_{SHUNT} is constrained by the supply voltage V_{DD} . The product of R_{SHUNT} , the current flowing through it, and the gain must not exceed V_{DD} ; otherwise; output distortion may occur. The table below provides recommended maximum values for R_{SHUNT} at different gain settings, assuming V_{DD} is 5V and the maximum current is 10A.

Device	RTQ6080-20	RTQ6080-50	RTQ6080-100	RTQ6080-200	RTQ6080-500
Gain	20V/V	50V/V	100V/V	200V/V	500V/V
Maximum R_{SHUNT} ($V_{DD} / (\text{Gain} \times I_{max})$)	25 m Ω	10 m Ω	5 m Ω	2.5 m Ω	1 m Ω
Power dissipation ($R_{SHUNT} \times I_{max}^2$)	2.5 W	1 W	0.5 W	0.25 W	0.1 W

18.2 Input Filtering Considerations

In some applications, the current being measured may be inherently noisy. When dealing with a noisy signal, filtering at the output of the current sense amplifier is often simpler; however, placing the filter at this location negates the advantage of the low output impedance provided by the internal buffer.

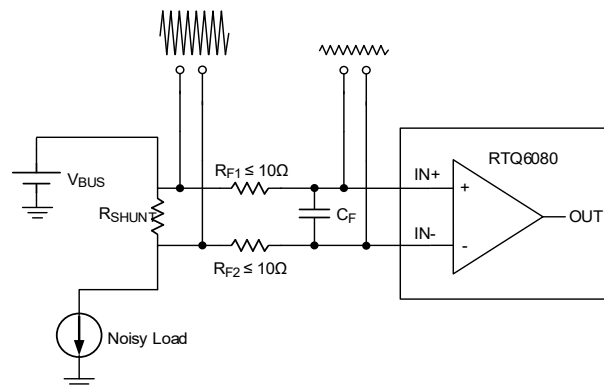


Figure 2. Input Filter

Other applications may require filtering at the input of the current sense amplifier. [Figure 2](#) shows the recommended schematic for input filtering.

Input filtering is complicated by the fact that mismatches between added resistance of the filter resistors and the associated circuit resistance can adversely affect gain, CMR, and offset voltage, V_{OS} . The effect on V_{OS} is partly due to input bias currents as well. As a result, the value of the input resistors should be limited to 10 Ω or less.

18.3 Total Error Analysis

To optimize the design, it is important to analyze each source of error. The main contributors to sense voltage errors can be identified as follows:

- Tolerance of the shunt resistor (RSHUNT)
- Sense offset voltage, V_{OS}. When the sense voltage is low, particularly at low load currents and with small shunt resistance, the error is dominated by the input offset error.
- Gain error, GE%
- Power supply rejection (PSR) of the offset voltage, PSR
- Common-mode rejection, CMR
- Offset voltage caused by input bias current
- Nonlinearity error, NLIN%

18.4 Maximum Output Error Estimation

Here is an example. The system bus voltage (V_{CM_SYS}) connects to VIN+ = 20V, system supply voltage (V_{DD_SYS}) = 3.3V, shunt resistor accuracy is 1%, 10mΩ 1.5W, and the load current is 10A. To set the design goals, the maximum output voltage errors are calculated in the following sections.

18.5 Input Offset Voltage Error

The contribution of offset error to the total error can be estimated directly from the specification table. The input offset voltage is 120μV at TA = 25°C. The error due to offset can be calculated using the following equation:

$$V_{OS_err} = \frac{V_{OS(max)}}{V_{SENSE}} \times 100\% = \frac{120\mu V}{10m\Omega \times 10A} \times 100\% = 0.12\%$$

18.6 Shunt Voltage Gain Error

From the Electrical Characteristics, the maximum gain error is 0.5% for RTQ6080.

18.7 PSR Error

The PSR error estimates the error caused by variations in supply voltages. The RTQ6080 device specification provides the input offset voltage specification at V_{DD_DS} = 5V. When the system supply voltage is not exactly 5V, it may result in an additional error. Calculate the PSR error using the equation below:

$$PSR_err = \frac{|V_{DD_DS} - V_{DD_SYS}| \times PSR}{V_{SENSE}} \times 100\%$$

$$= \frac{|5 - 3.3| \times 30 \frac{\mu V}{V}}{10m\Omega \times 10A} \times 100\% = 0.051\%$$

18.8 CMR Error

The CMR error means the input offset error is influenced by variations in the common-mode voltage. In real conditions, the maximum input offset should be calculated by determining the actual common-mode voltage applied to the RTQ6080. According to the RTQ6080 device specification, the minimum common-mode rejection ratio is 100dB (10μV/V). The offset voltage in the datasheet is specified with a common-mode voltage, V_{CM_DS}, of 12V. To calculate the actual common-mode error at the system bus voltage:

$$120dB = \frac{1}{10^{(\frac{100dB}{20})}} \times 10^6 \times \frac{\mu V}{V} = 1 \frac{\mu V}{V}$$

$$\begin{aligned} \text{CMR}_{\text{err}} &= \frac{|V_{\text{CM_DS}} - V_{\text{CM_SYS}}| \times \text{CMR}}{V_{\text{SENSE}}} \times 100\% \\ &= \frac{|12 - 20| \times 10 \frac{\mu\text{V}}{\text{V}}}{10\text{m}\Omega \times 10\text{A}} \times 100\% = 0.08\% \end{aligned}$$

18.9 Input Bias Current Error

The input bias current flowing through the shunt resistor causes an additional offset. This error is calculated with respect to the ideal voltage across the sense resistor:

$$\begin{aligned} I_{\text{B_err}} &= \frac{I_{\text{B}} \times R_{\text{SHUNT}}}{V_{\text{SENSE}}} \times 100\% = \frac{100\mu\text{A} \times 10\text{m}\Omega}{10\text{m}\Omega \times 10\text{A}} \times 100\% \\ &= 0.001\% \end{aligned}$$

18.10 Nonlinearity Error

The nonlinearity error, as shown in [Figure 3](#), is the difference between the actual gain and the ideal value. In ideal cases, the voltage gain is constant over the full sense range, but in real applications, the voltage gain is not exactly constant. Nonlinearity may cause additional errors. According to the specification, the RTQ6080 has a nonlinearity error of 0.01%.

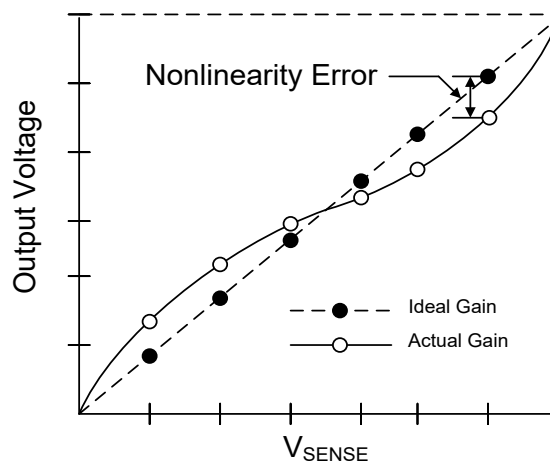


Figure 3. Nonlinearity Error

18.11 Total Error

Use the following equation to calculate the worst-case total error:

For RTQ6080 (GE = 0.5%):

Total_err =

$$\begin{aligned} &\sqrt{(GE\%)^2 + (R_{\text{SHUNT}}\%)^2 + (V_{\text{OS_err}})^2 + (PSR_{\text{err}})^2 + (\text{CMR}_{\text{err}})^2 + (I_{\text{B_err}})^2 + (\text{NLIN}\%)^2} \\ &= \sqrt{(0.5\%)^2 + (1\%)^2 + (0.12\%)^2 + (0.051\%)^2 + (0.08\%)^2 + (0.001\%)^2 + (0.01\%)^2} \\ &= 1.128\% \end{aligned}$$

18.12 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 125°C. The junction-to-ambient thermal resistance, θ_{JA} , is highly package dependent. For a SOT-23-5 package, the thermal resistance, θ_{JA} , is 192.7°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity two-layer test board. The maximum power dissipation at $T_A = 25^\circ\text{C}$ can be calculated as below:

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (192.7^\circ\text{C/W}) = 0.52\text{W for a SOT-23-5 package.}$$

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 4](#) allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

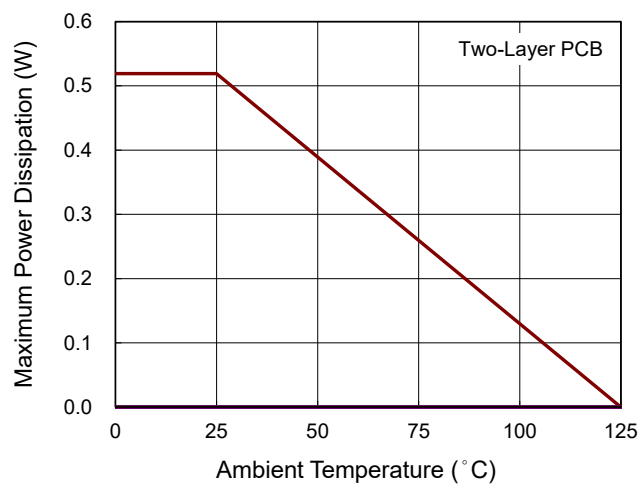


Figure 4. Derating Curve of Maximum Power Dissipation

18.13 Layout Guidelines

- For best performance, use a Kelvin sense arrangement. Connect the input pins (IN+ and IN-) to the sensing resistor using a 4-wire connection.
- PCB trace resistance from the sense resistor to the IN+ and IN- pins can affect power measurement accuracy. Place the sense resistors as close as possible to the RTQ6080 and avoid using minimum-width PCB traces.
- Place the power-supply bypass capacitor as close as possible to the supply and ground pins.

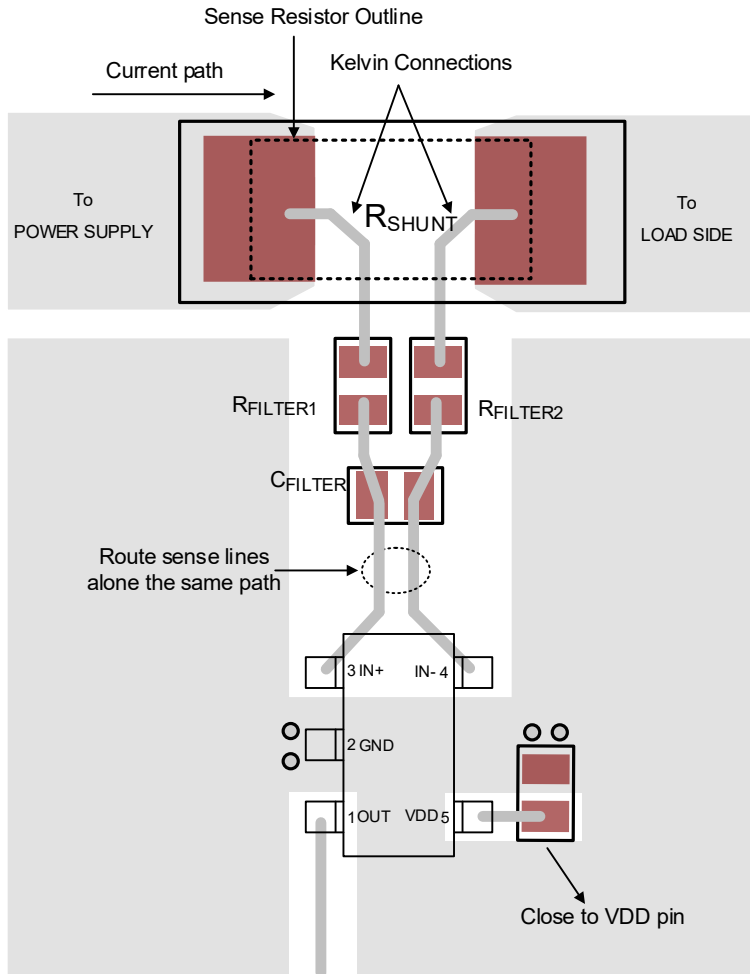
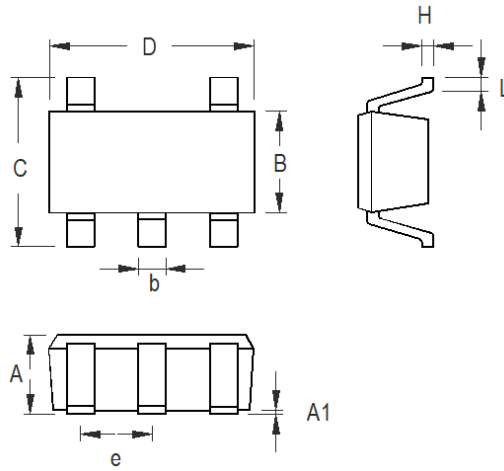


Figure 5. RTQ6080 PCB Layout Guide

Note 10. 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.

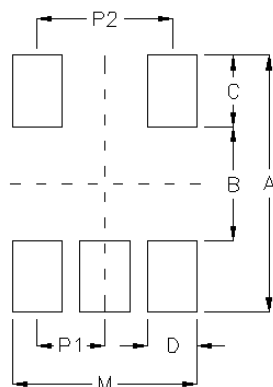
19 Outline Dimension



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

20 Footprint Information

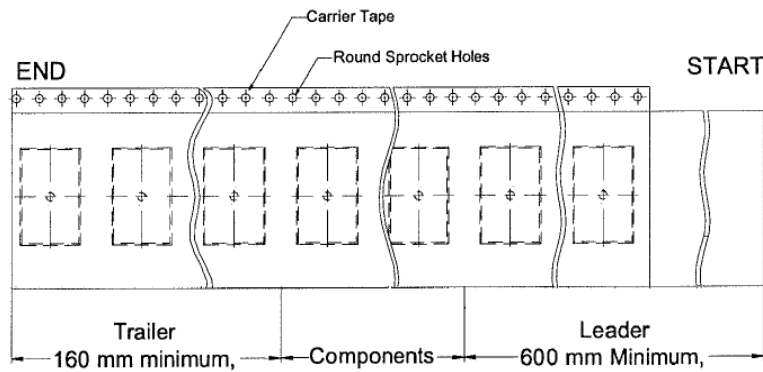
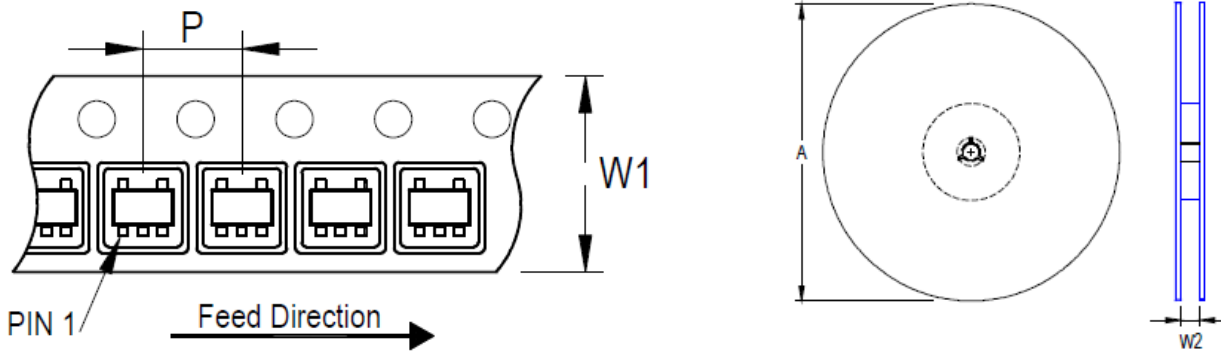


Package	Number of Pin	Footprint Dimension (mm)							Tolerance
		P1	P2	A	B	C	D	M	
TSOT-25/TSOT-25(FC)/SOT-25	5	0.95	1.90	3.60	1.60	1.00	0.70	2.60	±0.10

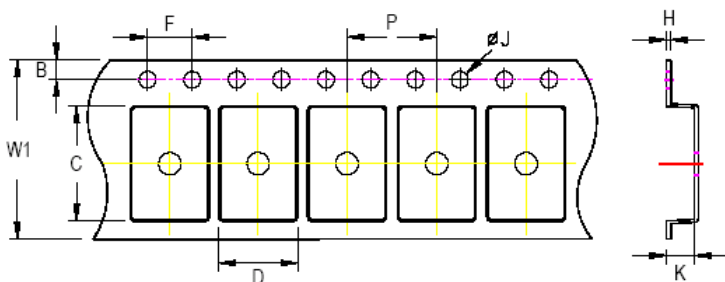
21 Packing Information

21.1 Tape and Reel Data

SOT/TSOT-23-5









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)				
SOT-23-5	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	1.3mm	1.7mm	0.6mm	

21.2 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

Package	Reel		Box			Carton		
	Size	Units	Item	Reels	Units	Item	Boxes	Unit
SOT-23-5	7"	3,000	Box A	3	9,000	Carton A	12	108,000
			Box E	1	3,000			

21.3 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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22 Datasheet Revision History

Version	Date	Description
00	2026/4/9	First Edition