RICHTEK®

RTQ6050/RTQ6052

High-Side Measurement Current Shunt Monitor with Comparator

1 General Description

The RTQ6050/RTQ6052 device is a high-side current-shunt monitor that contains a current-sense amplifier, a bandgap reference, and a comparator with a latching output. The RTQ6050/RTQ6052 senses voltage drops across shunts at common-mode voltages ranging from 2V to 80V. The RTQ6050/RTQ6052 series supports two output voltage scales: 20V/V, and 100V/V.

The RTQ6050 and RTQ6052 include an open-drain comparator and an internal reference providing a 0.6V threshold. External dividers set the current trip point. The comparator features a latching capability, which can be easily enabled by grounding (or leaving open) the RESET pin.

The RTQ6050/RTQ6052 is available in small 8-pins MSOP and SOP-8 packages. The recommended junction temperature range is –40°C to 125°C, and the ambient temperature range is –40°C to 85°C.

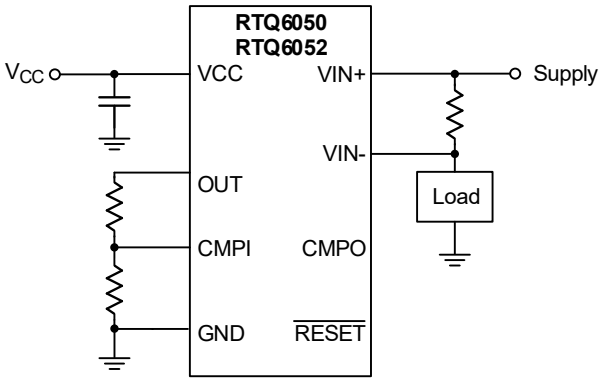
2 Features

- **High Accuracy Current Sensing**
- **3.5% Maximum Error Over-Temperature**
- **2.9V to 18V Power-Supply Range**
- **Two Gain Options Available**
  - **RTQ6050 = 20V/V**
  - **RTQ6052 = 100V/V**
- **Common-Mode Range: 2V to 80V**
- **0.6V Internal Voltage Reference**
- **Internal Open-Drain Comparator**
- **Latching Capability on Comparator**
- **Package: MSOP-8 and SOP-8**

3 Applications

- Server, Storage, and Network Equipment
- Portable, Battery-Powered Systems
- Point of Load (POL) Power Modules
- Notebook Computers
- High-End Digital TVs

4 Simplified Application Circuit



5 Ordering Information

Type A

RTQ605□□□

Package Type(1)
F: MSOP-8

Lead Plating System
G: Richtek Green Policy Compliant(2)

Gain Options
0: 20V/V
2: 100V/V

Type B

RTQ605□□-□□

Packing
A: Standard
Pin 1 Orientation
(Quadrant 1, Follow EIA-481)

Product Grade
T: Industrial Grade

Package Type(1)
S: SOP-8

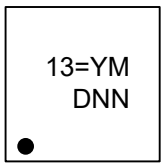
Gain Options
0: 20V/V
2: 100V/V

Note 1.

- Marked with (1) indicated: Compatible with the current requirements of IPC/JEDEC J-STD-020.
- Marked with (2) indicated: Richtek products are Richtek Green Policy compliant.

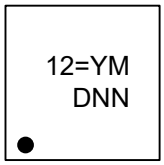
6 Marking Information

RTQ6050GF



13= : Product Code
YMDNN : Date Code

RTQ6052GF



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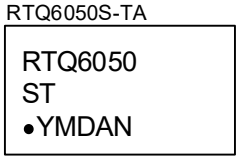
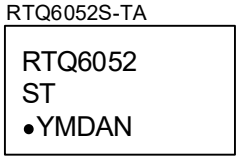


RTQ6050ST: Product Code
YMDAN: Date Code

RTQ6052S-TA

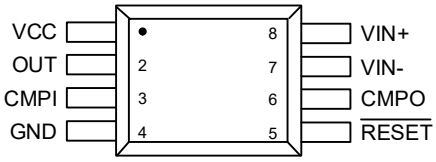


RTQ6052ST: Product Code
YMDAN: Date Code

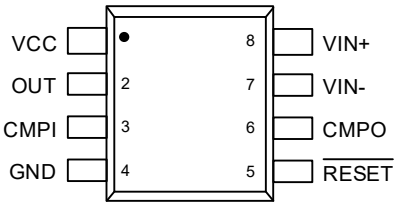
Table of Contents

7 Pin Configuration

(TOP VIEW)



MSOP-8

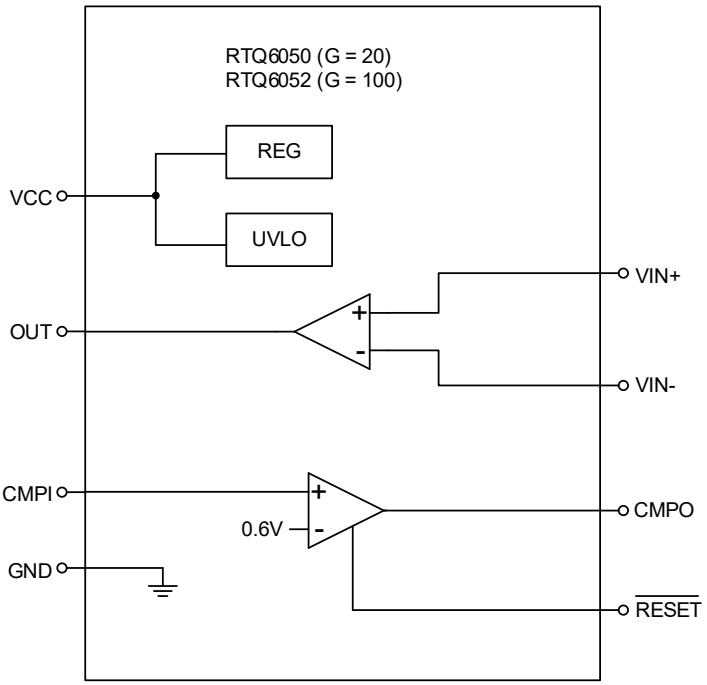


SOP-8

8 Functional Pin Description

Pin No.	Pin Name	Pin Function
1	VCC	Power input. Connect a 0.1μF capacitor as close to the VCC pin as possible.
2	OUT	Voltage output. V_{OUT} is proportional to V_{SENSE} (VIN+ – VIN-).
3	CMPI	Comparator input. Positive input of an internal comparator. The negative terminal is connected to a 0.6V internal reference.
4	GND	Ground.
5	$\overline{\text{RESET}}$	Reset input pin. Reset the output latch of the comparator, active low.
6	CMPO	Open-drain comparator output. Connect $\overline{\text{RESET}}$ to GND to disable the latch.
7	VIN-	Negative current-sensing input. Connect load side to external sense resistor.
8	VIN+	Positive current-sensing input. Connect power side to external sense resistor.

9 Functional Block Diagram



10 Absolute Maximum Ratings

(Note 2)

- Supply Input Voltage, V_{CC} ---------- –0.3V to 19.8V
- Power Sensing PINS, VIN+, VIN- (Common Mode), V_{CM} ---------- –6V to 88V
- Power Sensing PINS, VIN+ -VIN- (Differential Mode), V_{SENSE} ---------- –6V to 18V
- Other Pins, CMPI, CMPO, OUT, $\overline{RESET}$ ---------- –0.3V to 19.8V
- Power Dissipation, P_D @ T_A = 25°C

  MSOP-8 ---------- 0.47W

  SOP-8 ---------- 0.93W
- Package Thermal Resistance (Note 3)

  MSOP-8, θ_{JA} ---------- 214.69°C/W

  MSOP-8, θ_{JC} ---------- 37.8°C/W

  SOP-8, θ_{JA} ---------- 107.44°C/W

  SOP-8, θ_{JC} ---------- 19.5°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 4)

  HBM (Human Body Model) ---------- 4kV

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. 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.

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

11 Recommended Operating Conditions

(Note 5)

- Supply Input Voltage, V_{CC} ---------- 2.9V to 18V
- Common mode input range, V_{CM} ---------- 2V to 80V
- Ambient Temperature Range ---------- –40°C to 85°C
- Junction Temperature Range ---------- –40°C to 125°C

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

12 Electrical Characteristics

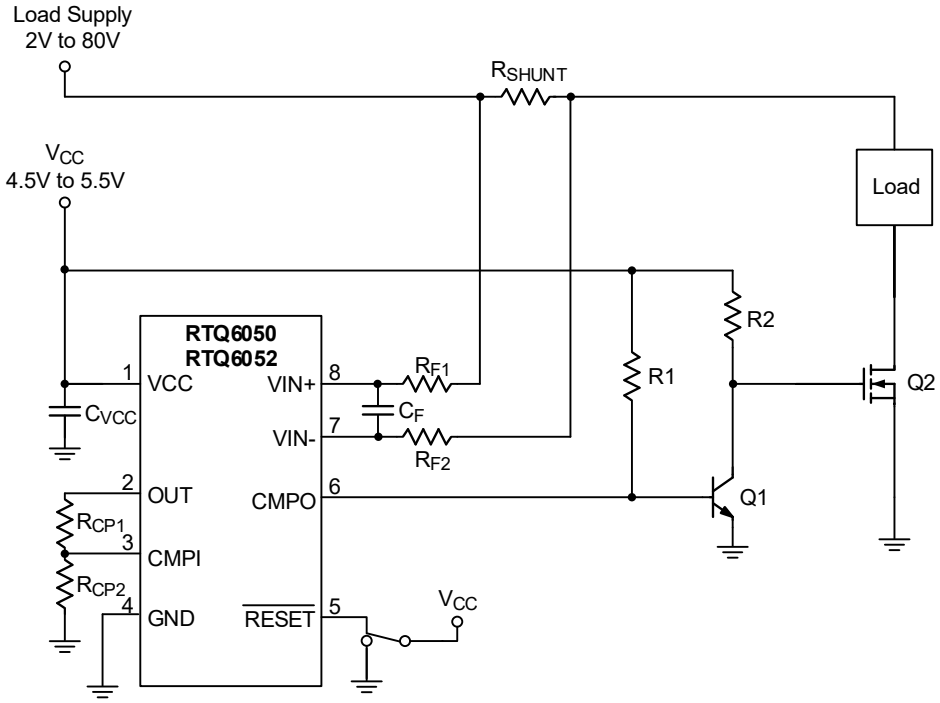
(V_{CC} = 12V, V_{CM} = 12V, T_A = 25°C, unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Power Supply							
Operating Power Supply	V_{CC}			2.9	--	18	V
Quiescent Current	I_Q	V_{OUT} = 2V, T_A = –40°C to 125°C		--	--	1200	µA
		V_{SENSE} = 0mV, T_A = –40°C to 125°C		--	--	500	
POR Rising Threshold	V_{POR_R}			2.7	2.75	2.85	V
POR Falling Threshold	V_{POR_F}			--	2.55	--	V
Current Sense							
Full Scale Sense Input Voltage				--	0.15	--	V
Common Mode Input Range	V_{CM}			2	--	80	V
Common Mode Rejection (Note 6)	CMR	V_{IN+} = 2V to 80V		80	100	--	dB
		V_{IN+} = 12V to 80V T_A = –40°C to125°C		100	123	--	dB
Offset Voltage, RTI	V_{OS}	T_A = 25°C		--	±0.5	±2.5	mV
		T_A = 25°C to 125°C		--	--	±3	mV
		T_A = –40°C to 125°C		--	--	±3.5	mV
Offset Voltage, RTI vs. Temperature (Note 6)		T_A = –40°C to 125°C		--	5	--	µV/°C
PSR of Offset Voltage, RTI	PSR	V_{OUT} = 2V, V_{IN+} = 18V, V_{CC} = 2.9V T_A = –40°C to 125°C		--	2.5	100	µV/V
Input Bias Current	I_B	VIN- pin		--	13	--	µA
Gain	G	RTQ6050		--	20	--	V/V
		RTQ6052		--	100	--	V/V
Gain Error	GE%	V_{SENSE} = 20mV to 100mV		--	±0.2	±1	%
		V_{SENSE} = 20mV to 100mV T_A = –40°C to 125°C		--	--	±2	%
Total Output Error	ΔV_{OUT}%	V_{SENSE} = 120mV, V_{CC} = 16V		--	±0.75	±2.2	%
		V_{SENSE} = 120mV, V_{CC} = 16V T_A = -40°C to 125°C		--	--	±3.5	%
Nonlinearity Error (Note 6)	NLIN%	V_{SENSE} = 20mV to 100mV		--	0.1	--	%
Maximum Capacitive Load (Note 6)		No sustained oscillation		--	10	--	nF
Output Voltage Range H		V_{IN-} =11V, V_{IN+}= 12V T_A = –40°C to 125°C		--	V_{CC} –0.15	--	V
Output Voltage Range L		V_{IN-} = 0V, V_{IN+} = –0.5V T_A = –40°C to 125°C	RTQ6050	--	4	100	mV
			RTQ6052	--	4	350	
Bandwidth (Note 6)	BW	GAIN = 20, C_{LOAD} = 5pF, unity gain		--	160	--	kHz

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
		GAIN = 100, C_{LOAD} = 5pF, unity gain		--	36	--	kHz
Phase Margin (Note 6)	PM	C_{LOAD} < 10nF		--	40	--	°
Slew Rate	SR	RTQ6050		--	0.5	--	V/μs
		RTQ6052		--	1.5	--	
Settling Time	T_{ST}	V_{SENSE} = 10mV to 100mV 10%~90% V_{OUT} C_{LOAD} = 5pF	RTQ6050	--	2	--	μs
			RTQ6052	--	6	--	
Noise Density, RTI (Note 6)		Frequency = 10k		--	40	--	nV/√Hz
Comparator							
Threshold	V_{TH}	T_A = –40°C to 125°C		585	600	615	mV
Hysteresis	V_{HYS}	T_A = –40°C to 85°C		--	–8	--	mV
Input Bias Current	I_{B_CM}	T_A = 25°C		--	0.005	10	nA
		T_A = –40°C to 125°C		--	--	15	nA
Maximum Input				--	V_{CC} –1.5	--	V
Output Open-Drain							
Voltage Gain (Note 6)	CMP_{GAIN}			--	200	--	V/mV
Leakage Current	I_{LEAK}			--	0.0001	1	μA
Dropout Voltage	V_{DROP}	I_{LOAD} = 2.35mA		--	125	220	mV
Response Time	T_{RS}	R_L to 5V, C_L = 15pF 100mV input step with 10mV overdrive		--	1.3	--	μs
$\overline{\text{RESET}}$							
$\overline{\text{RESET}}$ Pin Threshold	V_{RST_H}	High Level		1	--	--	V
	V_{RST_L}	Low Level		--	--	0.4	V
$\overline{\text{RESET}}$ Input Impedance				--	2	--	MΩ
$\overline{\text{RESET}}$ Minimum Pulse Width				--	1.5	--	μs
$\overline{\text{RESET}}$ Propagation Delay	t_{DLY_PD}			--	1.6	--	μs

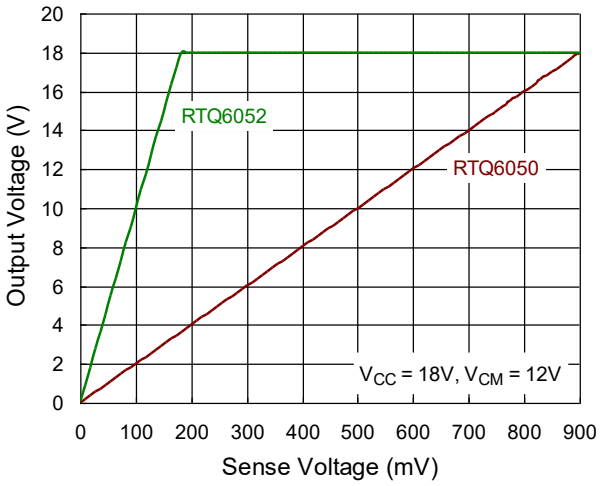
Note 6. Guaranteed by design.

13 Typical Application Circuit

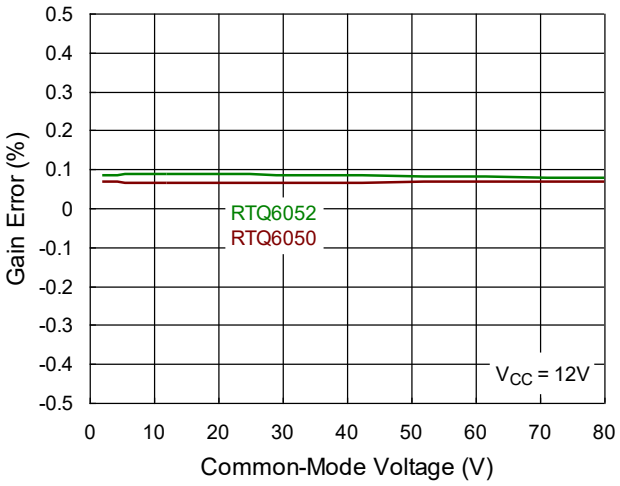


14 Typical Operating Characteristics

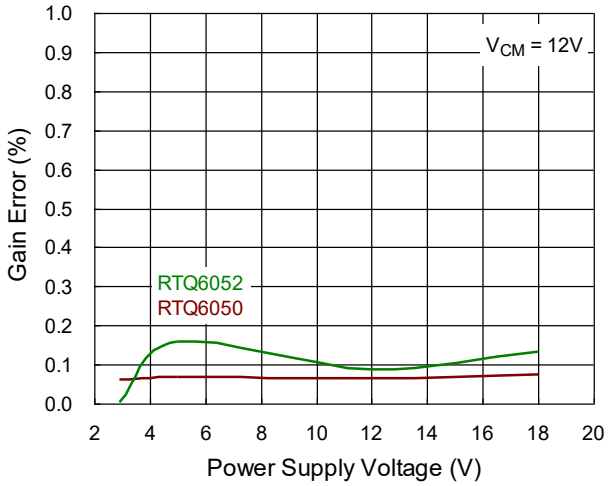
Output Voltage vs. Sense Voltage



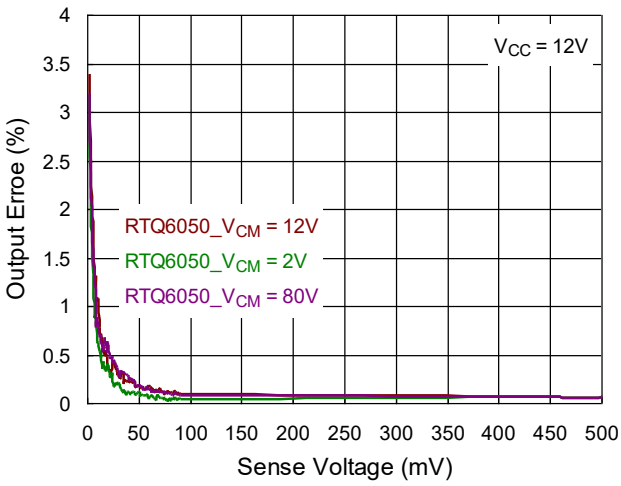
Gain Error vs. Common-Mode Voltage



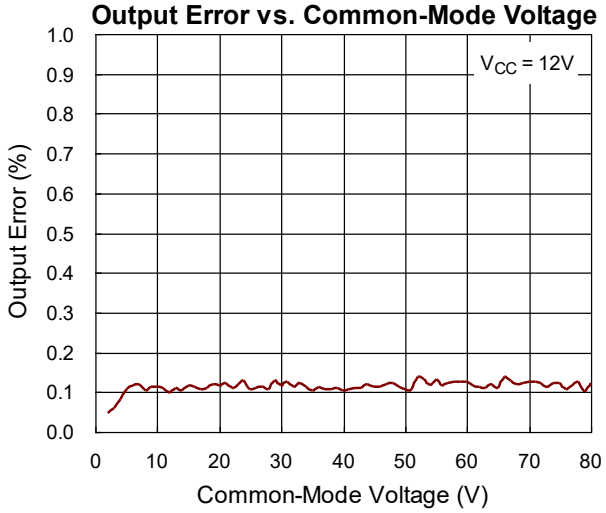
Gain Error vs. Power Supply Voltage



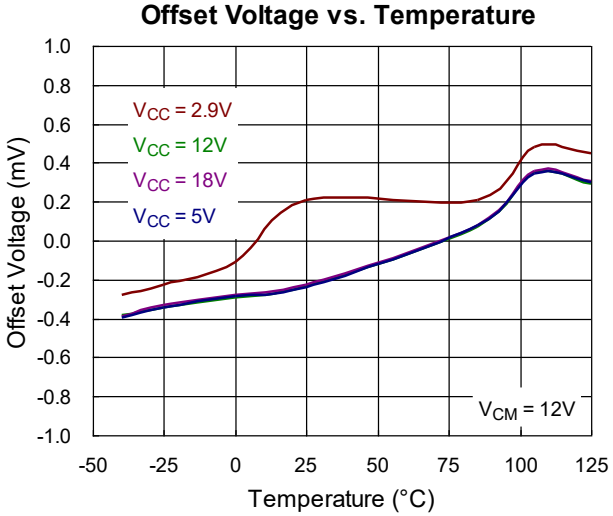
Output Error vs. Sense Voltage



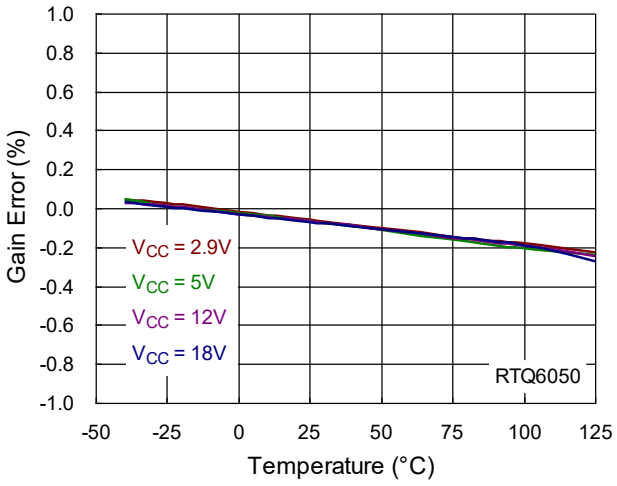
Output Error vs. Common-Mode Voltage



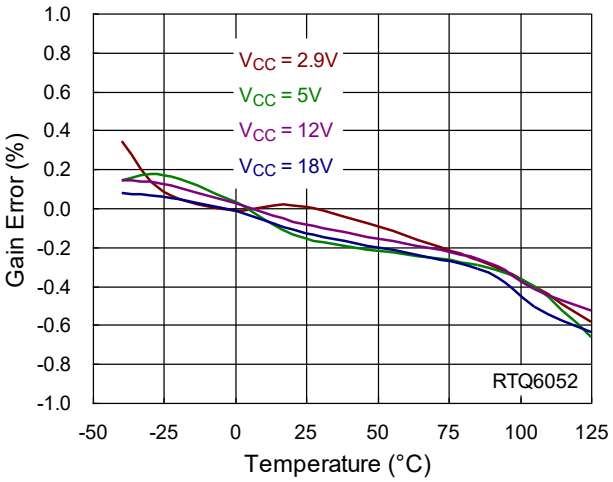
Offset Voltage vs. Temperature



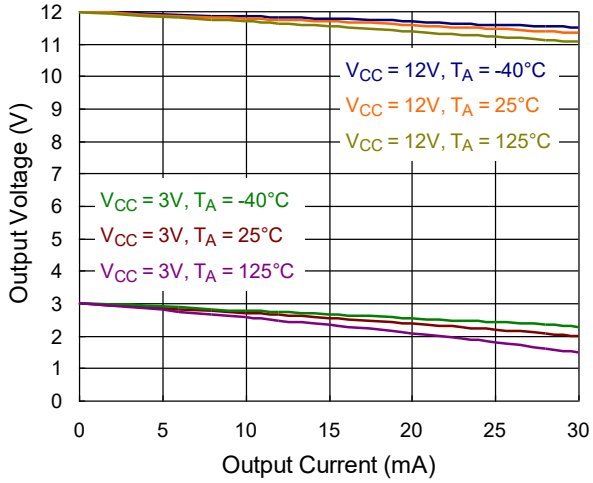
Gain Error vs. Temperature



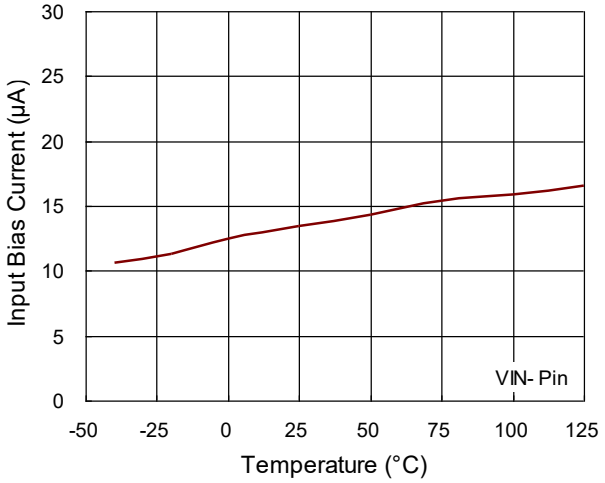
Gain Error vs. Temperature



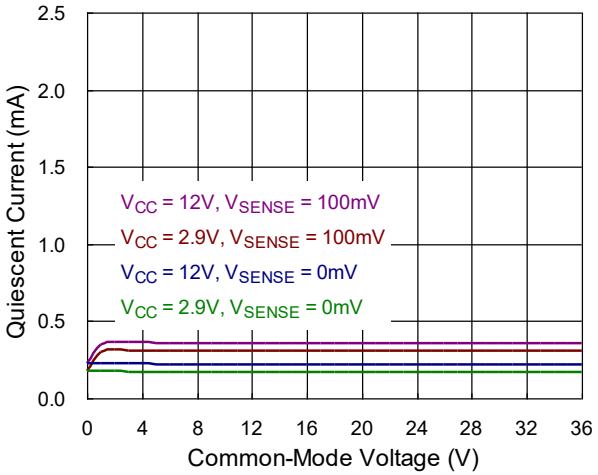
Output Voltage vs. Output Current



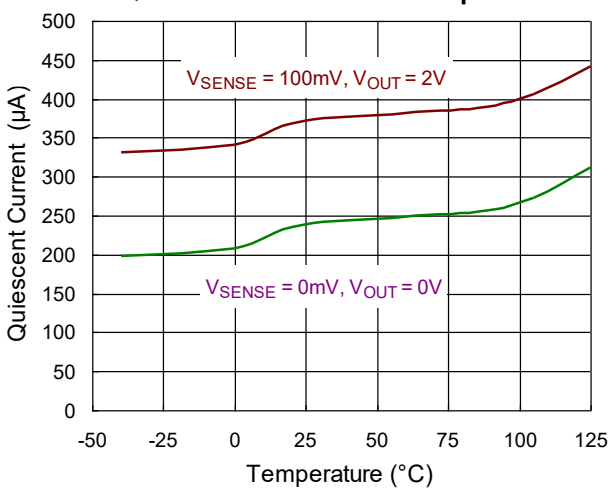
Input Bias Current vs. Temperature

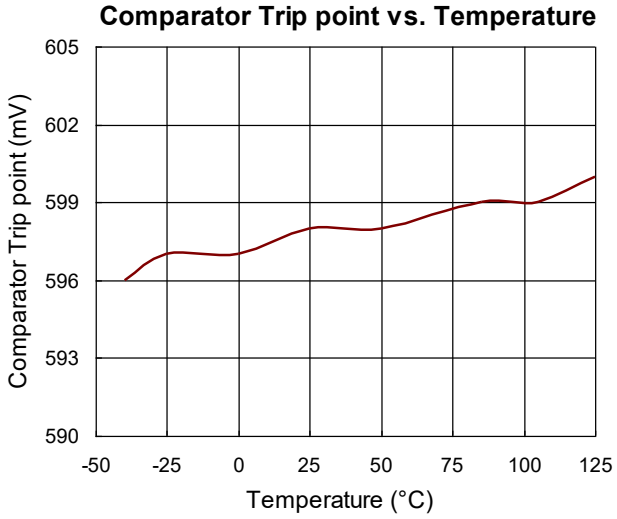


Quiescent Current vs. Common-Mode Voltage



Quiescent Current vs. Temperature





15 Operation

The RTQ6050/RTQ6052 devices are high-side, unidirectional current-shunt monitors with a high common-mode input range from 2V to 80V. The devices are available with two output voltage scales: 20V/V and 100V/V, with up to 500kHz bandwidth. Overcurrent protection is also available via an internal comparator; when the voltage at the CMPI pin is higher than the internal reference of 0.6V, the CMPO pulls high to indicate an overcurrent situation. Connect a divider from the OUT pin to the CMPI pin to set the overcurrent trip point. The devices provide an open-drain comparator with a latching function that allows the output signal of the comparator to be latched or non-latched by pin setting.

15.1 Comparator and Reset

The RTQ6050/RTQ6052 devices incorporate an open-drain comparator. This comparator typically has 1.3μs (typical) response time. The output of the comparator latches and is reset through the $\overline{\text{RESET}}$ pin. From Figure 1, the control logic is described in 3 stages.

Stage 1: V_{CMPO} goes high after V_{CMPI} increases and eventually exceeds 0.6V.

Stage 2: When V_{RESET} is high, V_{CMPO} is kept high even if V_{CMPI} decreases and falls below 0.6V; when the V_{RESET} goes low, V_{CMPO} also goes low.

Stage 3: When V_{RESET} is low, V_{CMPO} goes high/low depending on V_{CMPI} higher/lower than 0.6V.

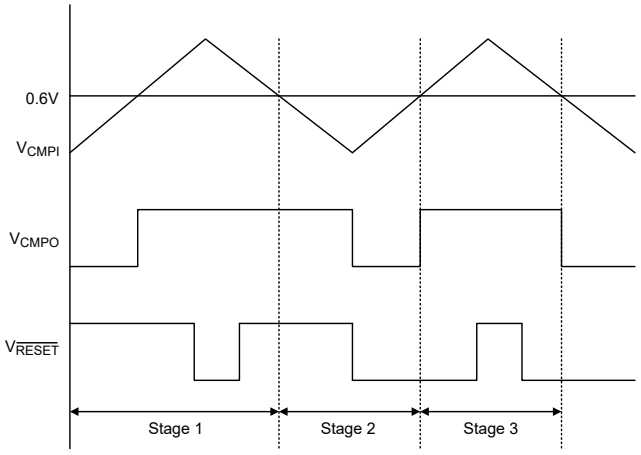
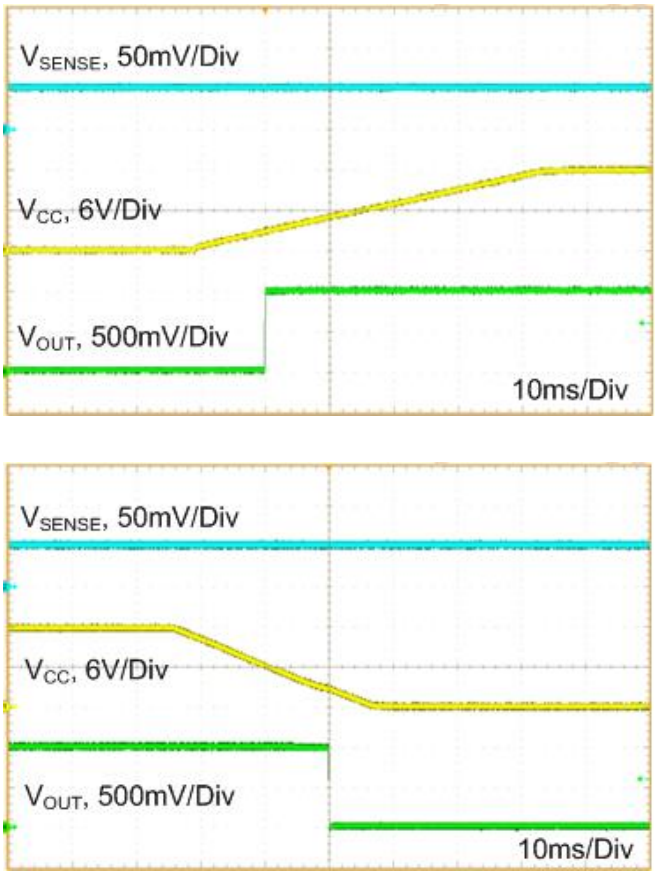


Figure 1. Comparator Latching and Reset Logic

15.2 Power On

The RTQ6050/RTQ6052 implements a power-on reset (POR) function to prevent operation without fully turning on the internal control circuit. When VCC increases and eventually becomes higher than the POR rising threshold (2.75V, typical), the device starts outputting voltage; in contrast, when VCC is lower than the POR falling threshold (2.55V, typical), the device stops outputting voltage.



15.3 Gain Error and Input Offset Voltage

Using a two-step method to characterize gain error and offset voltage, the gain can first be obtained by measuring the output voltage at different sense voltages.

$$G = \frac{V_{OUT1} - V_{OUT2}}{100mV\text{-}20mV}$$

where

- V_{OUT1} = output voltage with V_{SENSE} = 100mV
- V_{OUT2} = output voltage with V_{SENSE} = 20 V

Then, the offset voltage is measured at V_{SENSE} = 100mV, and is referred to the input (RTI) of the current shunt monitor, as shown in Electrical Characteristics: Current-Shunt Monitor.

$$VRTI\ (Referred\text{-}To\text{-}Input) = \left(\frac{V_{OUT1}}{G}\right) - 100mV$$

16 Application Information

(Note 7)

16.1 Selecting the Shunt Resistor

The selected value for the shunt resistor, RSHUNT, depends on the application and is a compromise between small-signal accuracy and the maximum permissible voltage loss in the measurement line. High values of RSHUNT provide better accuracy at lower currents by minimizing the effects of offset, while low values of RSHUNT minimize voltage loss in the supply line. For optimal performance, select RSHUNT to provide approximately 50mV to 100mV of sense voltage for the full-scale current for each application. The maximum input voltage for accurate measurements is 500mV, but the output voltage is limited by the supply voltage VCC.

16.2 Input Filtering

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.

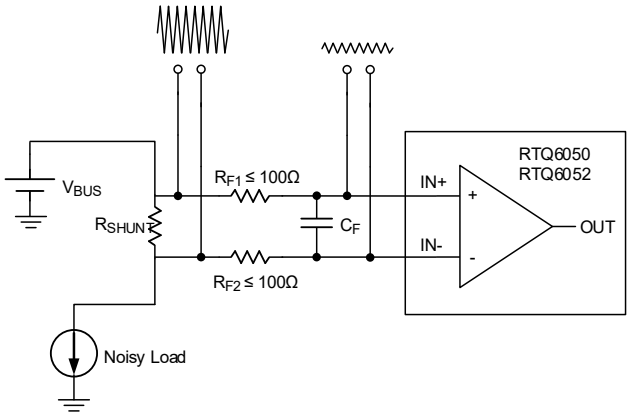


Figure 2. Input Filter

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 complexity arises from the potential mismatch between the added resistance of the filter resistors and the associated 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 100Ω or less.

16.3 Total Error Analysis

To optimize the design, the first is to analyze each error contributed; the main influences of sense voltage errors can be identified as follows:

- The tolerance of the shunt resistor (R_{SHUNT})
- Sense offset voltage, V_{OS}. When the sense voltage is low, particularly at low load currents and 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
- The offset voltage caused by input bias current

- Nonlinearity Error, NLIN%

16.4 Maximum Output Error Estimation

Consider the following example: The system bus voltage VCM_SYS is connected to VIN+ = 18V, and the system supply voltage VCC_SYS is 5V. The shunt resistor has an accuracy of 1%, with a value of 10mΩ and a power rating of 1.5W. The load current is 10A. To set the design goals, the maximum output voltage errors are calculated in the following sections.

16.5 Input Offset Voltage Error

The rate of offset error in the total error can be estimated directly from the specification table. The input offset voltage is 2.5mV at T_A = 25°C. The error due to offset can be obtained using the following equation:

$$V_{OS\_err} = \frac{V_{OS(max)}}{V_{SENSE}} \times 100\% = \frac{2.5mV}{10m\Omega \times 10A} \times 100\% = 2.5\%$$

16.6 Shunt Voltage Gain Error

From the Electrical Characteristics, the maximum gain error is 1%.

16.7 PSR Error

The PSR error estimates the error caused by different supply voltages. The RTQ6050/RTQ6052 device specification provides the specified power supply voltage for the input offset voltage specification as V_{CC_DS} = 2.9V. When the system supply voltage is not exactly 2.9V, it may result in an additional error. The RTQ6050/RTQ6052 device specifies the maximum PSR as 100μV/V. Calculate the PSR error using the equation below:

$$PSR\_err = \frac{\left|V_{CC\_DS} - V_{CC\_SYS}\right| \times PSR}{V_{SENSE}} \times 100\%$$

$$= \frac{\left|2.9 - 5\right| \times 100\frac{\mu V}{V}}{10m\Omega \times 10A} \times 100\% = 0.21\%$$

16.8 CMR Error

The CMR error means the input offset error is influenced by variations of the common-mode voltage. In real conditions, calculate the maximum input offset by determining the actual common-mode voltage as applied to the RTQ6050/RTQ6052. According to the RTQ6050/RTQ6052 device specification, the minimum common-mode rejection ratio is given as 80dB (100μV/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:

$$80dB = \frac{1}{10^{\left(\frac{80dB}{20}\right)}} \times 10^6 \times \frac{\mu V}{V} = 100\frac{\mu V}{V}$$

$$CMR\_err = \frac{\left|V_{CM\_DS} - V_{CM\_SYS}\right| \times CMR}{V_{SENSE}} \times 100\%$$

$$= \frac{\left|12 - 18\right| \times 100\frac{\mu V}{V}}{10m\Omega \times 10A} \times 100\% = 0.6\%$$

16.9 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 voltage.

$$I_{B\_err} = \frac{I_B \times R_{SHUNT}}{V_{SENSE}} \times 100\% = \frac{13\mu A \times 10m\Omega}{10m\Omega \times 10A} \times 100\%$$

$$= 0.00013\%$$

16.10 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. The nonlinearity gain may cause additional errors. In the specification, the RTQ6050/RTQ6052 gives the nonlinearity error as 0.1% over a sense voltage range from 20mV to 100mV.

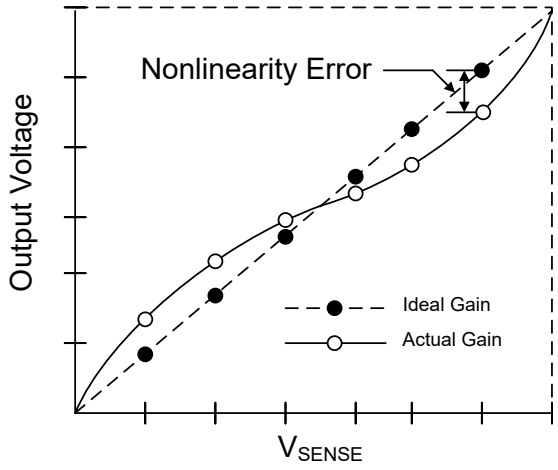


Figure 3. Nonlinearity Error

16.11 Total Error

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

$$Total\_err = \sqrt{(GE\%)^2 + (R\%)^2 + (V_{OS\_err})^2 + (PSR\_err)^2 + (CMR\_err)^2 + (I_{B\_err})^2 + (NLIN\%)^2}$$

$$= \sqrt{(1\%)^2 + (1\%)^2 + (2.5\%)^2 + (0.21\%)^2 + (0.6\%)^2 + (0.0013\%)^2 + (0.1\%)^2}$$

$$= 2.94\%$$

16.12 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 MSOP-8 package, the thermal resistance, θ_{JA}, is 214.69°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. For a SOP-8 package, the thermal resistance, θ_{JA}, is 107.44°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 below:

$P_{D(MAX)}$ = (125°C – 25°C) / (214.69°C/W) = 0.47W for a MSOP-8 package;

$P_{D(MAX)}$ = (125°C – 25°C) / (107.44°C/W) = 0.93W for a SOP-8 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 curves in Figure 4 allow the user to see the effect of rising ambient temperature on the maximum power dissipation.

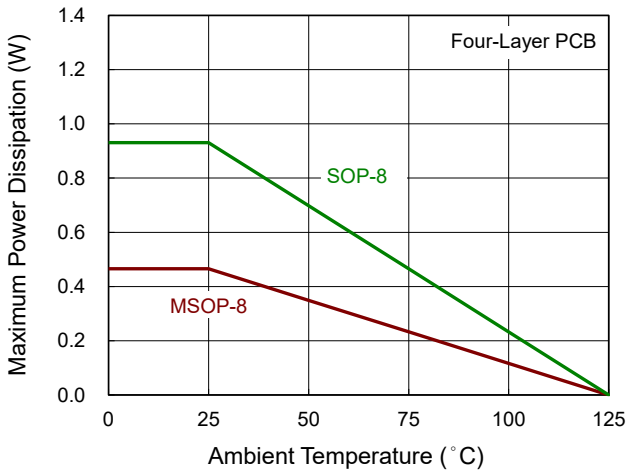


Figure 4. Derating Curve of Maximum Power Dissipation

16.13 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 RTQ6050/RTQ6052 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.

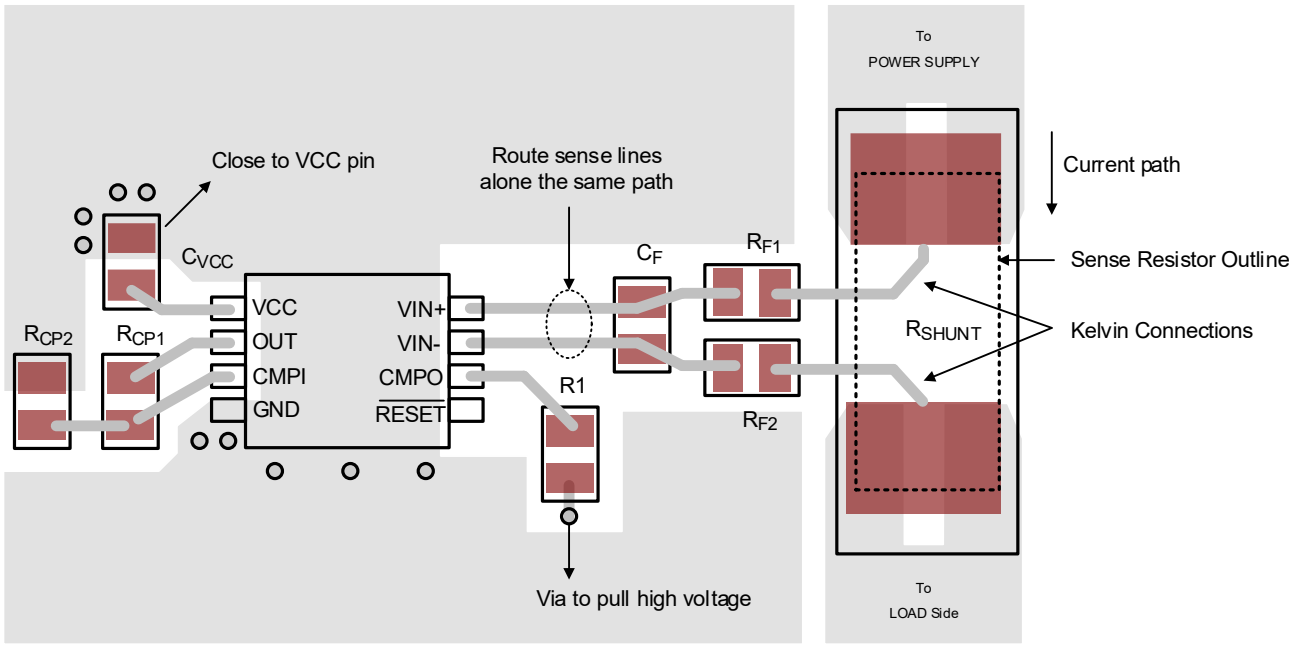
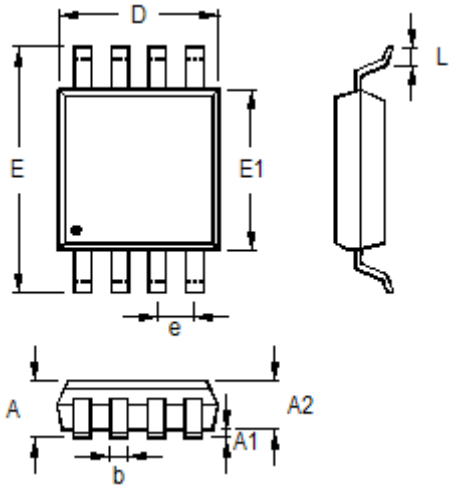


Figure 5. PCB Layout Guide

Note 7. The information provided in this section is for reference only. The customer is solely responsible for the designing, validating, and testing your product incorporating Richtek's product and ensure such product meets applicable standards and any safety, security, or other requirements.

17 Outline Dimension

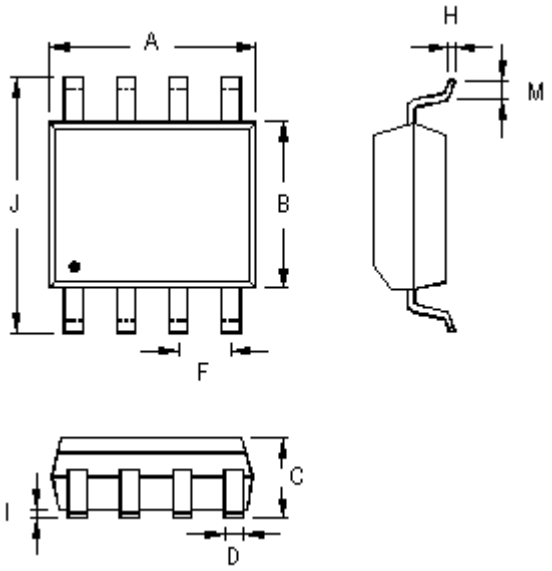
17.1 MSOP-8 Package



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.810	1.100	0.032	0.043
A1	0.000	0.150	0.000	0.006
A2	0.750	0.950	0.030	0.037
b	0.220	0.380	0.009	0.015
D	2.900	3.100	0.114	0.122
e	0.650		0.026	
E	4.800	5.000	0.189	0.197
E1	2.900	3.100	0.114	0.122
L	0.400	0.800	0.016	0.031

8-Lead MSOP Plastic Package

17.2 SOP-8 Package

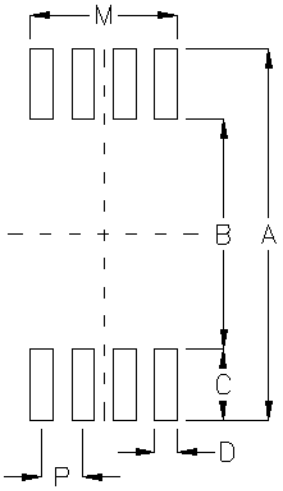


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.801	5.004	0.189	0.197
B	3.810	3.988	0.150	0.157
C	1.346	1.753	0.053	0.069
D	0.330	0.508	0.013	0.020
F	1.194	1.346	0.047	0.053
H	0.170	0.254	0.007	0.010
I	0.050	0.254	0.002	0.010
J	5.791	6.200	0.228	0.244
M	0.400	1.270	0.016	0.050

8-Lead SOP Plastic Package

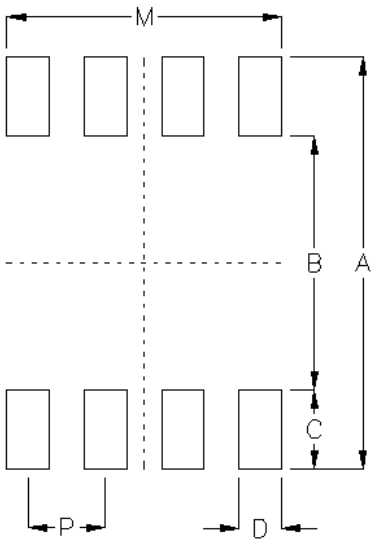
18 Footprint Information

18.1 MSOP-8 Package



Package	Number of Pin	Footprint Dimension (mm)						Tolerance
		P	A	B	C	D	M	
MSOP-8	8	0.65	5.80	3.60	1.10	0.35	2.30	±0.10

18.2 SOP-8 Package

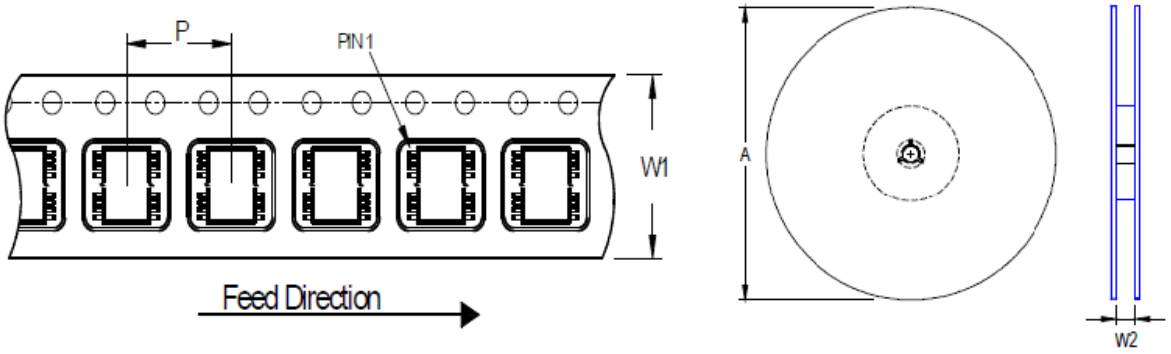


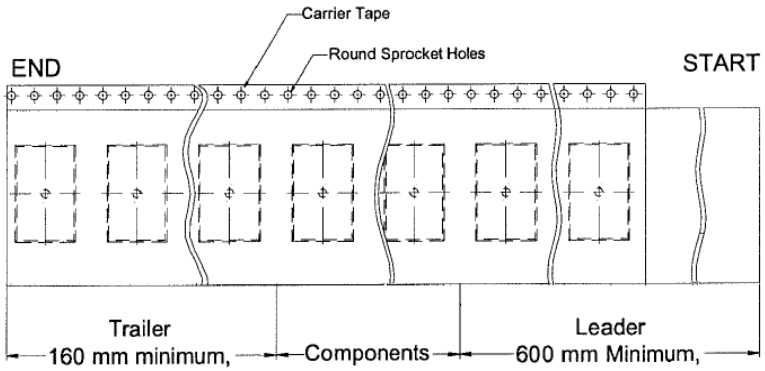
Package	Number of Pin	Footprint Dimension (mm)						Tolerance
		P	A	B	C	D	M	
SOP-8/SOP-8(FC)	8	1.27	6.80	4.20	1.30	0.70	4.51	±0.10

19 Packing Information

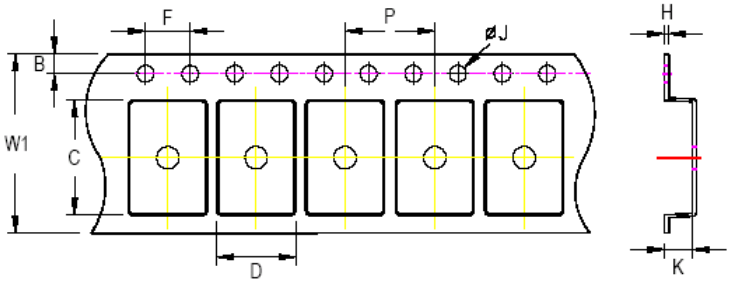
19.1 Tape and Reel Data

19.1.1 MSOP-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)				
MSOP-8	12	8	330	13	2,500	160	600	12.4/14.4

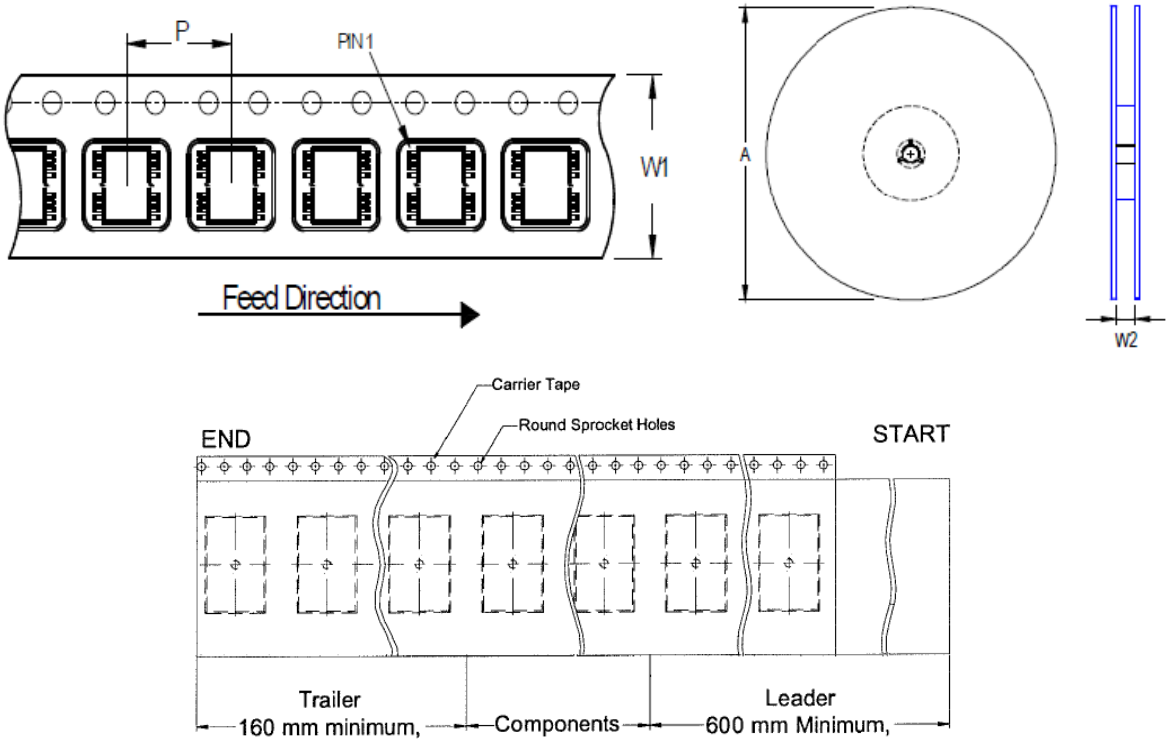


C, D, and K are determined by component size. The clearance between the components and the cavity is as follows:

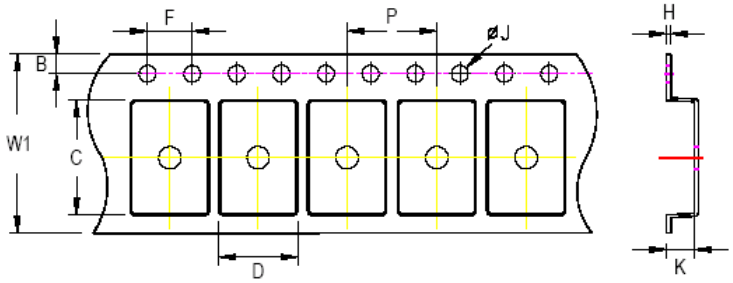
- For 12mm carrier tape: 0.5mm max.

Tape Size	W1	P		B		F		ØJ		K		H
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max
12mm	12.3mm	7.9mm	8.1mm	1.65mm	1.85mm	3.9mm	4.1mm	1.5mm	1.6mm	1.5mm	1.7mm	0.6mm

19.1.2 SOP-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)				
SOP-8	12	8	330	13	2,500	160	600	12.4/14.4



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

- For 12mm 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
12mm	12.3mm	7.9mm	8.1mm	1.65mm	1.85mm	3.9mm	4.1mm	1.5mm	1.6mm	1.9mm	2.2mm	0.6mm

19.2 Tape and Reel Packing

19.2.1 MSOP-8

Step	Photo/Description	Step	Photo/Description
1	 Reel 13”	4	 1 reel per inner box **Box G**
2	 HIC & Desiccant (2 Unit) inside	5	 6 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	Units
MSOP-8	13”	2,500	Box G	1	2,500	Carton A	6	15,000

19.2.2 SOP-8

Step	Photo/Description	Step	Photo/Description
1	 Reel 13”	4	 1 reel per inner box **Box G**
2	 HIC & Desiccant (2 Unit) inside	5	 6 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	Units
SOP-8	13”	2,500	Box G	1	2,500	Carton A	6	15,000

19.3 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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20 Datasheet Revision History

Version	Date	Description
00	2022/03/24	First Edition
01	2022/11/23	*General Description* *Features* *Applications* *Simplified Application Circuit* *Ordering Information* *Marking Information* *Functional Block Diagram* *Operation* *Electrical Characteristics* *Typical Application Circuit* *Typical Operating Characteristics* *Application Information* - Added RTQ6050
02	2025/1/22	*General Description* *Ordering Information* *Functional Block Diagram* *Application Information* *Packing Information* - Updated
03	2025/8/7	General Description Features Ordering Information Marking Information Pin Configuration Absolute Maximum Ratings Outline Dimension Footprint Information Packing Information - Added SOP-8 package Absolute Maximum Ratings - Updated MSOP-8 package Thermal Considerations - Added