

General Description

The SQ52134C is a 50V/V fixed gain, low-power, high-precision, high-side or low-side current-sense amplifier with ultra-low input bias current, suitable for bidirectional or unidirectional current measurements. The common mode voltage range of the SQ52134C is from -24V to +55V, independent of the supply voltage. Its common mode voltage down to -24V is suitable for the inductive load scenario, because this loads such as motors or solenoids can cause negative voltages under inductive kickback or transient changes.

The SQ52134C has an ultra-low input bias current (500pA typical). Compared with other current-sense amplifiers, this feature allows larger current-sense resistors to be used to enable current measurements in the micro-ampere range.

The supply voltage range of the SQ52134C is 1.8V to 5.5V and the device draws 62 μ A quiescent current. It is available in a SOT363 package and is specified over the extended industrial temperature range of -40°C to 125°C.

Features

- Wide Common-mode Voltage Range, V_{CM} : -24V to +55V
- Low Input Bias Currents, I_B : 500pA (Typ.)
- Fixed Gain: 50V/V
- High-Accuracy:
 - Offset Voltage, V_{OS} : $\pm 54\mu$ V (Max.)
 - Offset Drift: $\pm 0.25\mu$ V/°C (Max.)
 - Gain Error: $\pm 0.6\%$ (Max.)
 - Gain Drift: ± 10 ppm/°C (Max.)
 - Common-mode Rejection Ratio: 134 dB (Min.)
- Low Supply Voltage, V_{CC} : 1.8V to 5.5V
- Low Quiescent Current, I_Q : 62 μ A (Typ.)
- Package: SOT363
- MSL Rating: MSL1

Applications

- Smartphones
- Battery Management Systems (BMS)
- Servers
- Notebook PCs
- Telecom equipment
- Power management

Typical Application

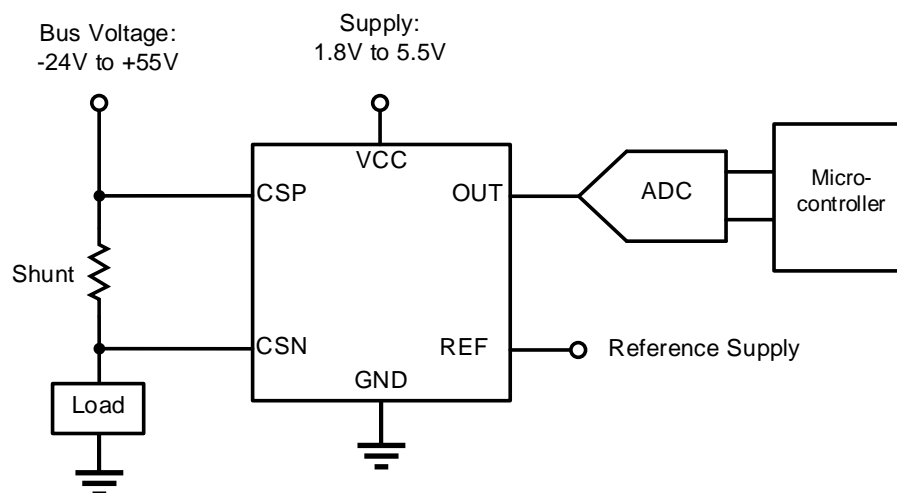


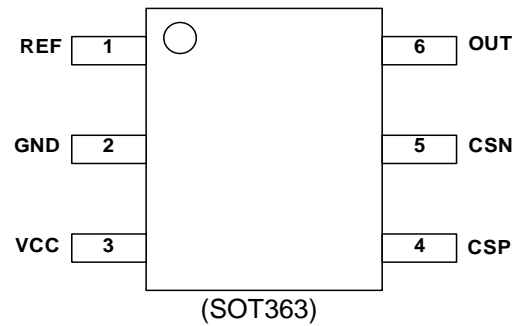
Figure 1. Simplified Application Circuit

Ordering Information

Ordering Part Number	Package Type	Top Mark
SQ52134CAHT	SOT363	Axyz ^①

Note ①: x=year code, y=week code, z=lot number code.

Pin out (Top View)



Pin Description

Pin No	Pin Name	Pin Description
1	REF	Reference voltage input, 0V to VCC.
2	GND	Ground.
3	VCC	Power supply, 1.8 V to 5.5 V.
4	CSP	Connect to supply side of shunt resistor.
5	CSN	Connect to load side of shunt resistor.
6	OUT	Amplifier Output.

Block Diagram

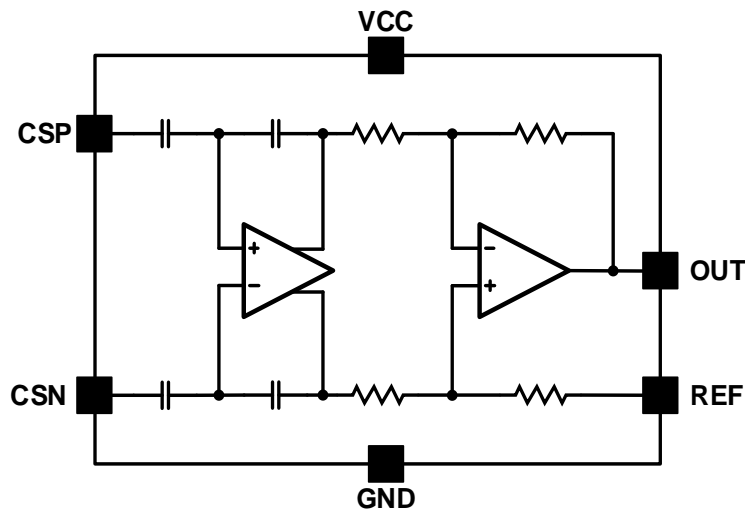


Figure 2. Block Diagram



Absolute Maximum Ratings

Parameter (Note 1)	Min	Max	Unit
VCC	-0.3	6	V
CSP-CSN (Differential)	-40	40	
CSP, CSN (Common-Mode)	GND-26	60	
Output	GND-0.3	VCC+0.3	
Input Current into Any Pin		5	mA
Operating Temperature	-40	125	°C
Storage Temperature Range	-65	150	
ESD: HBM (Human Body Model)	± 2000		V
ESD: CDM (Charged Device Model)	± 1000		V

Parameter (Note 2)	Max	Unit
θ_{JA} Junction-to-ambient Thermal Resistance	321	°C/W
θ_{JC} Junction-to-case Thermal Resistance	60	
P_D Power Dissipation $T_A = 25^\circ\text{C}$	0.31	W

Recommended Operating Conditions

Parameter (Note 3)	Min	Max	Unit
Supply Voltage	1.8	5.5	V
Common-mode, CSP, CSN	GND-24	55	
Reference Voltage Range	GND	VCC	
Operating Free-air Temperature	-40	125	°C



Electrical Characteristics

$T_A=25^{\circ}\text{C}$, $V_{\text{SENSE}} = V_{\text{CSP}} - V_{\text{CSN}}$, $V_{\text{CC}} = 1.8\text{ V to }5.0\text{ V}$, $V_{\text{CM}} = 12\text{ V}$, $V_{\text{REF}} = V_{\text{CC}} / 2$, unless otherwise noted. (Note 4)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input						
Common Mode Input Voltage	V_{CM}	$T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$	-24		55	V
Common Mode Rejection Ratio, RTI (Note 6)	CMRR	$V_{\text{SENSE}} = 0\text{ mV}$, $V_{\text{CM}} = -24\text{ V to }55\text{ V}$, $T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$	134	150		dB
Offset Voltage, RTI	V_{OS}	$V_{\text{CC}} = 1.8\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$		-0.5	± 54	μV
Offset Voltage Drift	dV_{OS}/dT	$V_{\text{SENSE}} = 0\text{ mV}$, $T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$		± 0.05	± 0.25	$\mu\text{V}/^{\circ}\text{C}$
Power Supply Rejection Ratio, RTI	PSRR	$V_{\text{SENSE}} = 0\text{ mV}$, $V_{\text{CC}} = 1.8\text{ V to }5.5\text{ V}$		-1	± 10	$\mu\text{V/V}$
Input Bias Current	I_{B}	$V_{\text{SENSE}} = 0\text{ mV}$		0.5	3	nA
Input Offset Current	I_{OS}	$V_{\text{SENSE}} = 0\text{ mV}$		± 0.07		nA
Output						
Gain	G			50		V/V
Gain Error	E_{G}	$V_{\text{OUT}} = 0.1\text{ V to }V_{\text{CC}} - 0.1\text{ V}$		± 0.07	± 0.6	%
		$T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$		± 2	± 10	ppm/ $^{\circ}\text{C}$
Non-linearity Error (Note 5)		$V_{\text{OUT}} = 0.1\text{ V to }V_{\text{CC}} - 0.1\text{ V}$		± 0.01		%
Reference Voltage Rejection Ratio	RVRR	$V_{\text{REF}} = 100\text{ mV to }V_{\text{CC}} - 100\text{ mV}$, $T_A = -40^{\circ}\text{C to }+125^{\circ}\text{C}$		± 2	± 10	$\mu\text{V/V}$
Maximum Capacitive Load (Note 5)		No sustained oscillation		1		nF
Voltage Output						
Swing to V_{CC} Power Supply Rail	VSP	$V_{\text{CC}} = 1.8\text{ V}$, $R_{\text{L}} = 10\text{ k}\Omega$ to GND, $T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$		$(V_{\text{CC}}) - 0.02$	$(V_{\text{CC}}) - 0.04$	V
Swing to GND	VSN	$V_{\text{CC}} = 1.8\text{ V}$, $R_{\text{L}} = 10\text{ k}\Omega$ to GND, $T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$, $V_{\text{SENSE}} = -10\text{ mV}$, $V_{\text{REF}} = 0\text{ V}$		$(V_{\text{GND}}) + 0.05$	$(V_{\text{GND}}) + 1$	mV
Zero Current Output Voltage	VZL	$V_{\text{CC}} = 1.8\text{ V}$, $R_{\text{L}} = 10\text{ k}\Omega$ to GND, $T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$, $V_{\text{SENSE}} = 0\text{ mV}$, $V_{\text{REF}} = 0\text{ mV}$		$(V_{\text{GND}}) + 2$	$(V_{\text{GND}}) + 4$	mV
Frequency Response (Note 5)						
Bandwidth	BW	$C_{\text{LOAD}} = 10\text{ pF}$		50		kHz
Slew Rate	SR	$V_{\text{CC}} = 5.0\text{ V}$, $V_{\text{OUT}} = 0.5\text{ V to }4.5\text{ V}$		0.3		V/ μs
Settling Time	t_{s}	From current step to within 1% of final value		30		μs
Noise, RTI (Note 5)						
Voltage Noise Density				75		nV/ $\sqrt{\text{Hz}}$
Power Supply						
Supply Voltage	V_{CC}	$T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$	1.8		5.5	V
Quiescent Current	I_{Q}	I_{Q} vs temperature, $T_A = -40^{\circ}\text{C to }125^{\circ}\text{C}$		62	75	μA
Specified Temperature Range			-40		125	$^{\circ}\text{C}$

Note 1: Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: Package thermal resistance is measured in the natural convection at $T_A=25^{\circ}\text{C}$ on an 8.5cm \times 8.5cm size single-layer Silergy Evaluation Board.

Note 3: The device is not guaranteed to function outside its operating conditions.

Note 4: Unless otherwise stated, limits are 100% production tested at $T_A \approx T_J = 25^{\circ}\text{C}$. Limits over the operating temperature range (see recommended operating conditions) and relevant voltage range(s) are guaranteed by design, test, or statistical correlation.

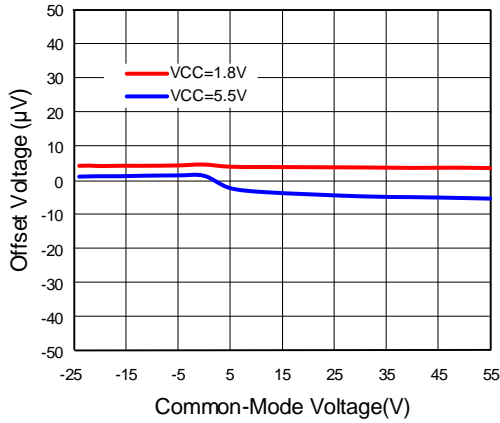
Note 5: Guaranteed by design or statistical correlation and not production tested.

Note 6: RTI = Referred to Input.

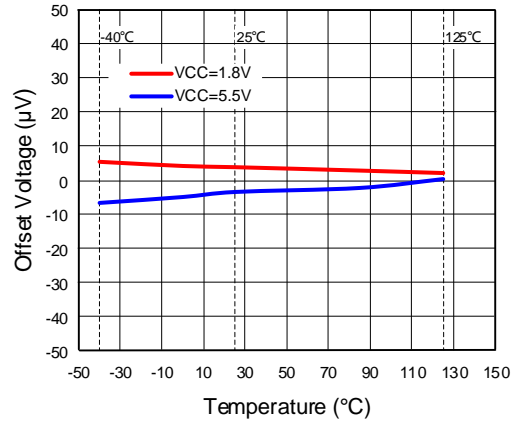
Typical Performance Characteristics

($T_A=25^{\circ}\text{C}$, $V_{\text{SENSE}} = V_{\text{CSP}} - V_{\text{CSN}}$, $V_{\text{CC}} = 5.0\text{ V}$, $V_{\text{CM}} = 12\text{ V}$, $V_{\text{REF}} = V_{\text{CC}} / 2$, unless otherwise noted.)

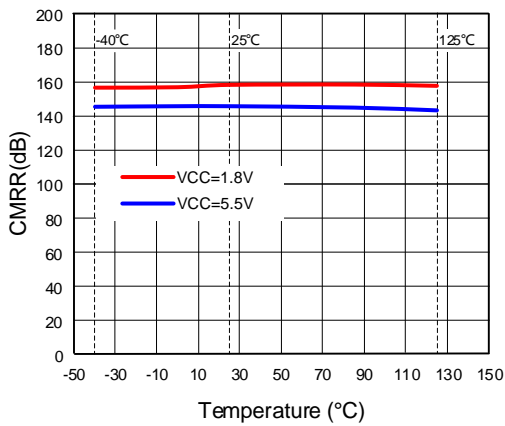
Offset Voltage vs. Common-Mode Voltage



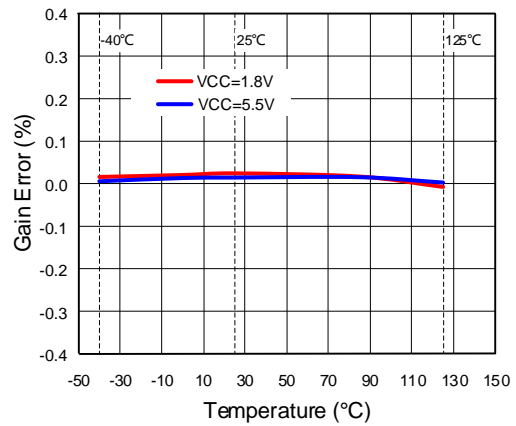
Offset Voltage vs. Temperature



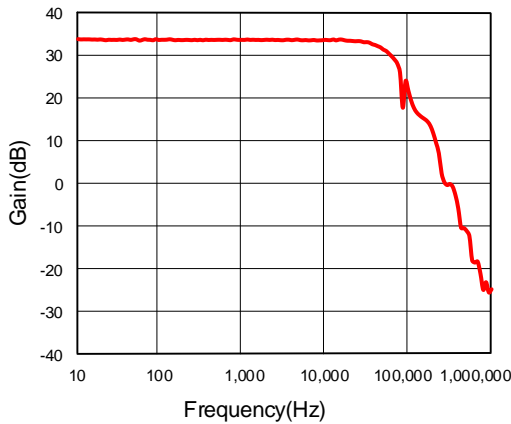
Common-Mode Rejection Ratio vs. Temperature



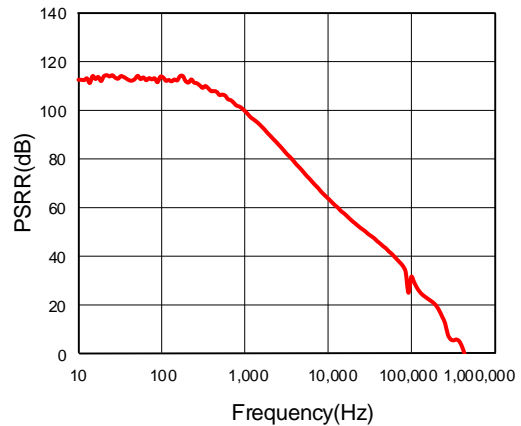
Gain Error vs. Temperature



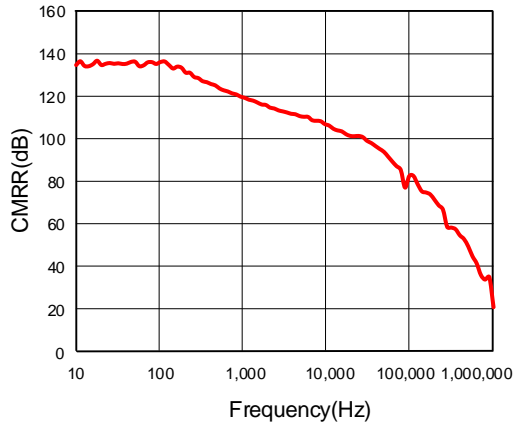
Gain vs. Frequency



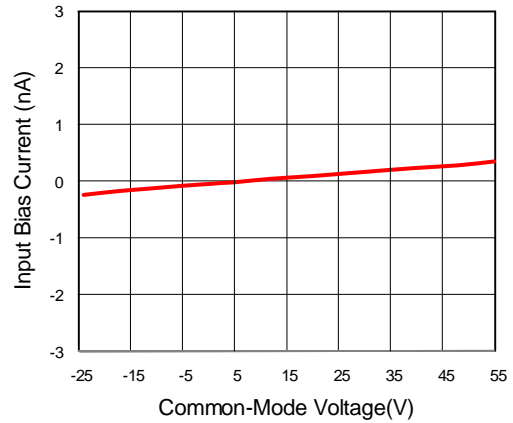
Power-Supply Rejection Ratio vs. Frequency



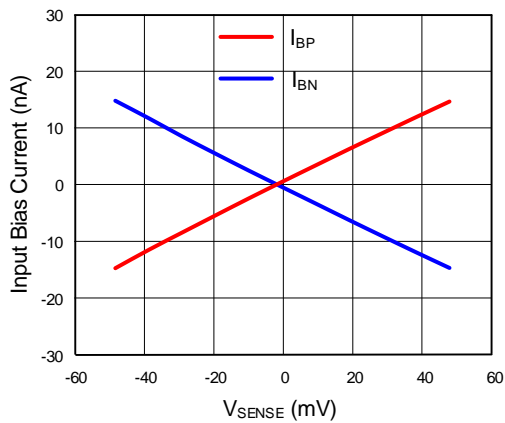
Common-Mode Rejection Ratio vs. Frequency



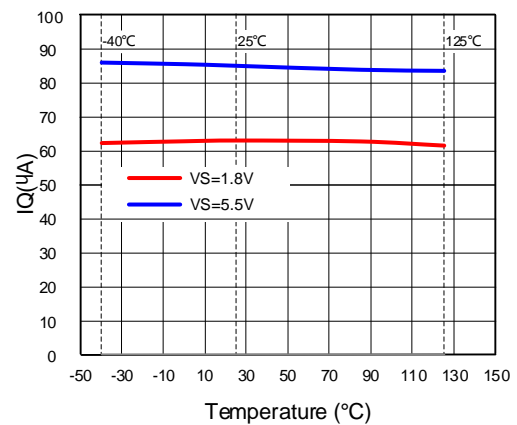
Input Bias Current vs. Common-Mode Voltage



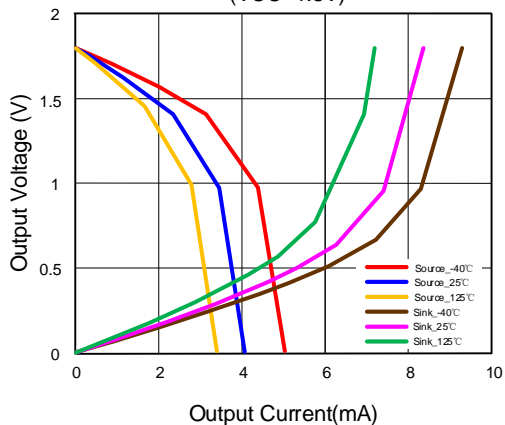
Input Bias Current vs. V_{SENSE}



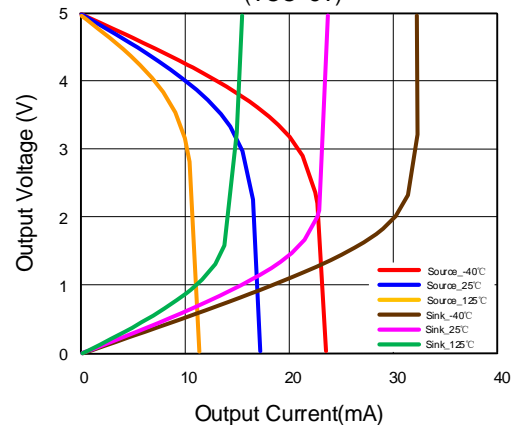
Quiescent Current vs. Temperature



Output Voltage vs. Output Current
(VCC=1.8V)



Output Voltage vs. Output Current
(VCC=5V)



Application Information

The SQ52134C is an ultra-low input bias current, low-power, fixed gain current-sense amplifier that can sense current by amplifying the differential voltage across an external shunt resistor on common-mode voltages to create an output voltage. Its -24V to +55V wide common-mode range and high-precision enable it used in high-precision, high- and low-side applications.

Low Input Bias Current

The SQ52134C uses a capacitively coupled amplifier on the input stage, which results in an ultra-low input bias current, this feature can bring two benefits:

1. Low bias current allows larger current-sense resistors to be used to accurately measurements currents as low as 1 μA , and allows use input filters to improve the system signal-to-noise ratio (SNR).
2. Low bias current has the ability to be used at low-power applications. Classical current-sense amplifier typically consume tens or hundreds of microamps of bias current at the inputs, the loss of the amplifier is composed of this bias current and quiescent current, the ultra-low input bias current and low quiescent current of the SQ52134C make it suitable for low-power applications.

High-Side and Low-Side Current Sensing

The SQ52134C has -24V to +55V input common mode voltage range, which is independent of the supply voltage. This ability allows the current to be monitored during low-side conditions, while also enabling high-side current sensing above the supply voltage, as shown in the *Figure 3*.

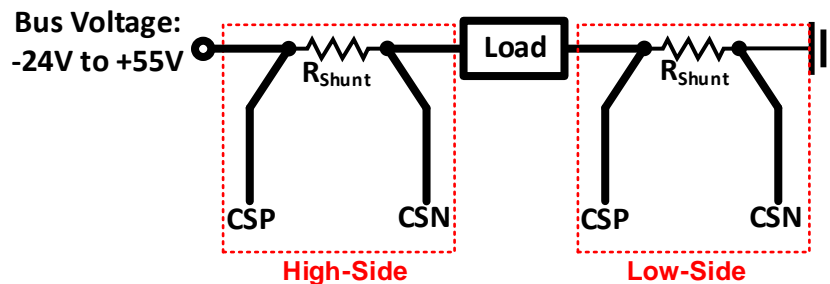


Figure 3. High-Side and Low-Side Current Sensing

REF Input

The SQ52134C will measure the voltage developed across a current-sense resistor when current passes through the device. The transfer function of SQ52134C is

$$OUT = 50 \times V_{SENSE} + V_{REF} \quad (V_{SENSE} = V_{CSP} - V_{CSN})$$

This ability allows the SQ52134C applicable to unidirectional and bidirectional current sensing.

It should be noted that the linear output range of the SQ52134C is 1mV to $V_{CC} - 0.04V$, it means the output will saturate low condition with small input signal when the REF pin is connected to ground and output will saturate high condition with small input signal when the REF pin is connected to VCC. In order to achieve ideal linear amplification, it is necessary to ensure that the output voltage is between 1mV and $V_{CC} - 0.04V$.

For unidirectional current-sense application, the REF pin can be connected to ground directly as *Figure 4* shown. When the input signal increases, the output voltage will increase. When very low input currents need to be measured, the REF pin needs to be biased to a convenient value above 1mV to bring the output into the linear range of the device.

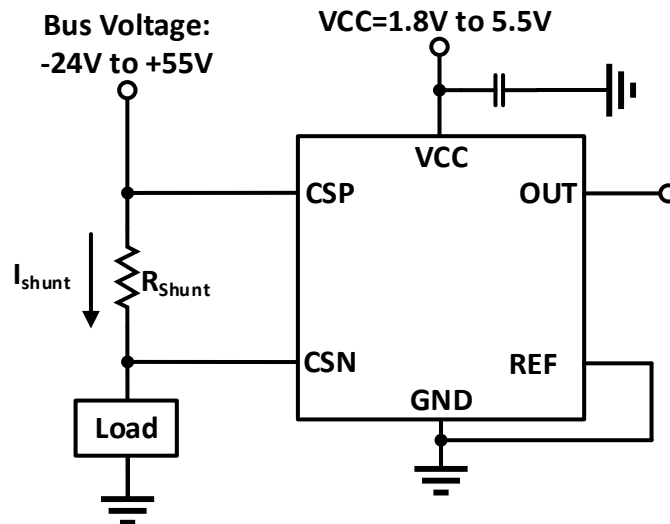


Figure 4. Unidirectional Current-sense Application

For bidirectional current-sense application, the REF pin can be connected to a reference voltage (for example $0.5 \times V_{CC}$) as Figure 5 shown. The output rises above the reference voltage for positive differential input signals and falls below the reference voltage for negative differential input signals linearly.

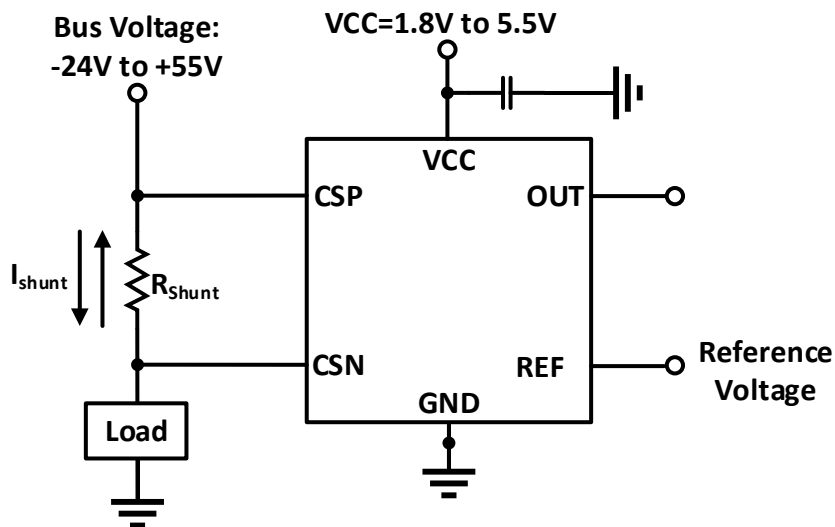


Figure 5. Bidirectional Current-sense Application

Like any differential amplifier, the common mode rejection ratio of the SQ52134C is affected by any impedance present at the REF input. This problem will not exist when the REF pin is connected directly to most reference or power supplies. When using a resistor divider from the power supply or a reference voltage, the REF pin must be buffered by an OP AMP as Figure 6 shown.

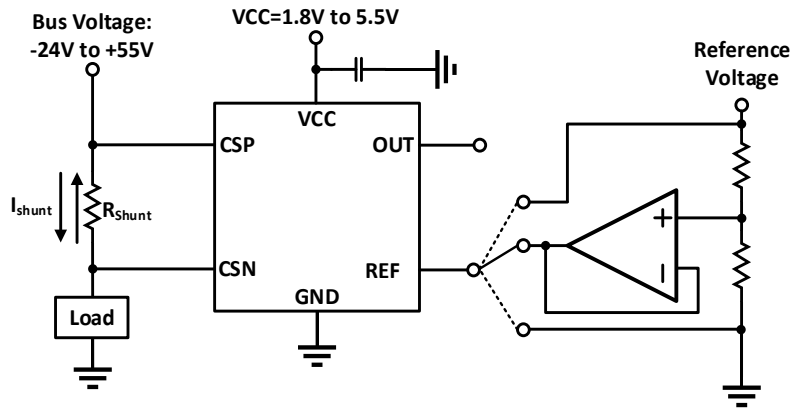


Figure 6. REF Pin Drive

In the system where using a differential input analog-to-digital converter (ADC) or using two separate single-ended input ADCs, the differential voltage of the OUT pin and the REF pin of the SQ52134C can be directly collected. This detection method can eliminate the influence of external impedance on the REF input, where the REF pin can be driven directly with a divider resistor without going through the buffer. As shown in Figure 7.

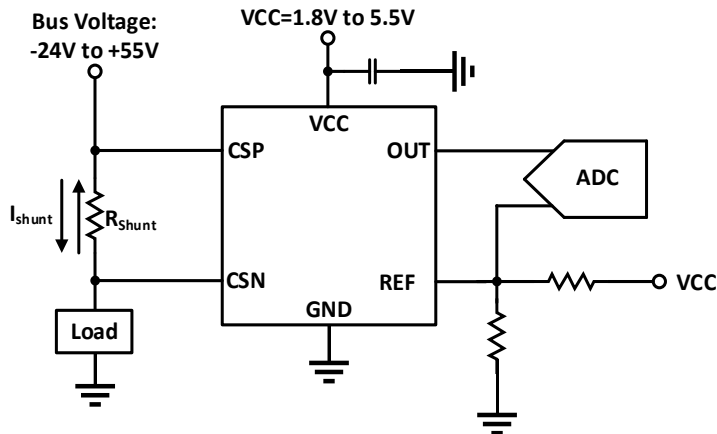


Figure 7. Sensing the SQ52134C to Cancel the Effects of Impedance on the REF Input

Input Filtering

To improve the de-glitch ability and the system SNR (Signal to Noise Ratio). It's recommended to place a RC filter at the inputs pins is as below shows.

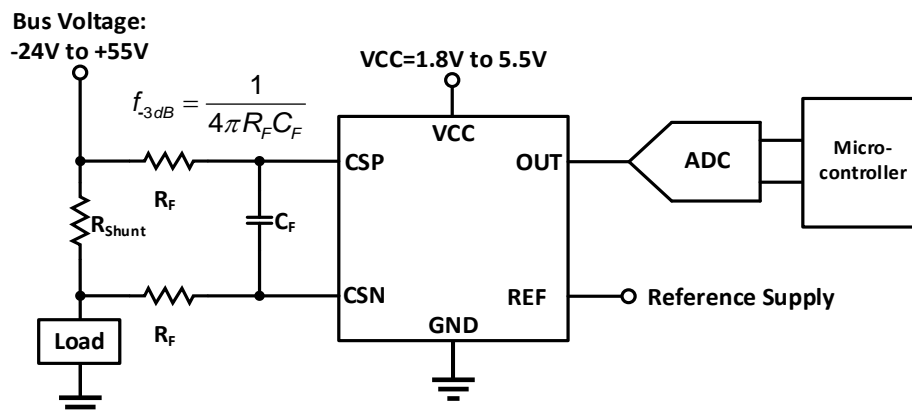


Figure 8. Filter at Input Pins



Selecting RSENSE

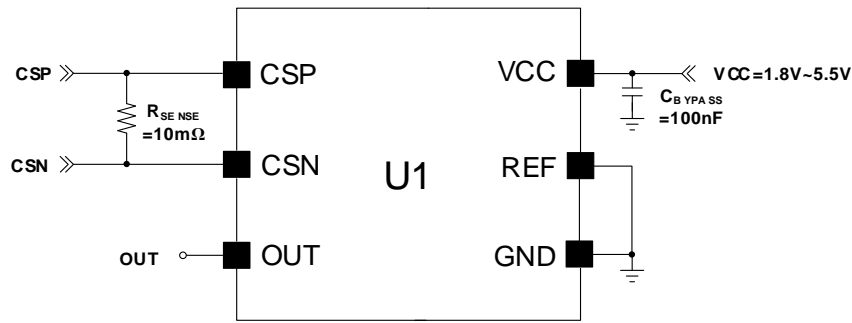
The value of the current sense resistor is influenced by the measured current, the range of the differential input voltage, the reference voltage V_{REF} and the power supply voltage. Additionally, the output swing also impact the resistor value. The presence of offset voltage, gain error, and other parameters in the current sense amplifier necessitates choosing the largest possible sense resistor to maximize the differential signal value, reduce detection errors, and enhance measurement accuracy. However, due to OUT voltage swing, the size of the resistor value will be subject to certain limitations.

A quick design table are shown as below:

Unidirectional Application ($V_{REF}=0V$)			Bidirectional Application ($V_{REF}=0.5 \times VCC$)		
I_{SENSE} range	Recommended R_{SENSE}		I_{SENSE} range	Recommended R_{SENSE}	
	VCC=5V	VCC=1.8V		VCC=5V	VCC=1.8V
0 μ A ~ 100 μ A	990 Ω	350 Ω	-100 μ A ~ 100 μ A	490 Ω	170 Ω
0mA ~ 10mA	9.9 Ω	3.5 Ω	-10mA ~ 10mA	4.9 Ω	1.7 Ω
0A ~ 1A	99m Ω	35m Ω	-1A ~ 1A	49m Ω	17m Ω
0A ~ 10A	9.9m Ω	3.5m Ω	-10A ~ 10A	4.9m Ω	1.7m Ω



Application Schematic



BOM List

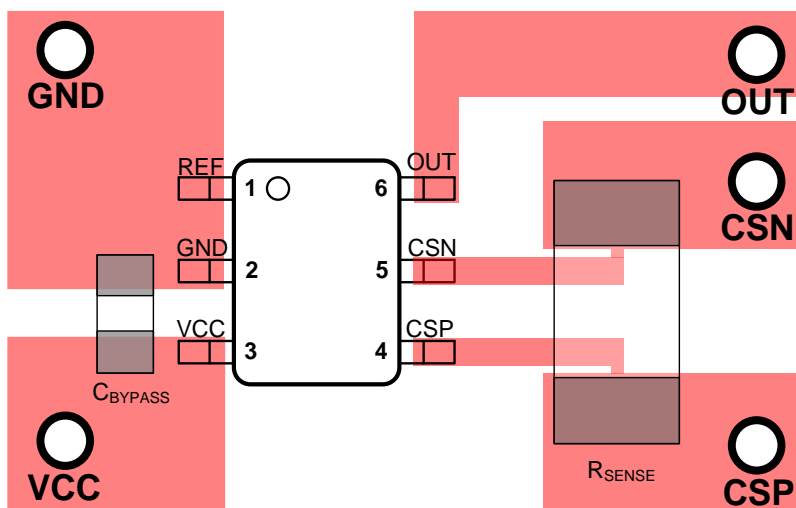
Designator	Description	Part Number	MFR
C _{BYPASS}	100nF/50V/X7R, 0603	GCJ188R71H104KA12D	muRata
R _{SENSE}	10mΩ/1W, 2512, 1%	RL2512FK-070R01L	YAGEO

PCB Layout Guide

For optimal design, follow these PCB layout guidelines:

Use a Kelvin connection to connect the input pins to the current-sense resistor R_{SENSE}. Due to the low resistance values of R_{SENSE}, poor PCB routing often leads to additional parasitic resistance between input pins, resulting in additional errors. This connection method ensures that only R_{SENSE} impedance is detected between the input pins. Minimize the loop formed by these connections.

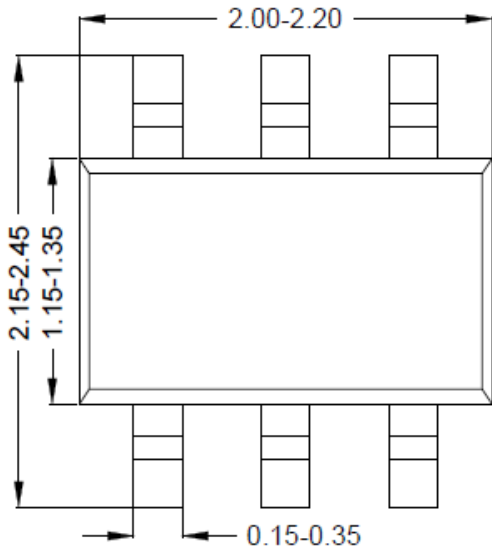
Place the bypass capacitor (a 0.1μF MLCC is recommended) as close as possible to the VCC and GND pins.



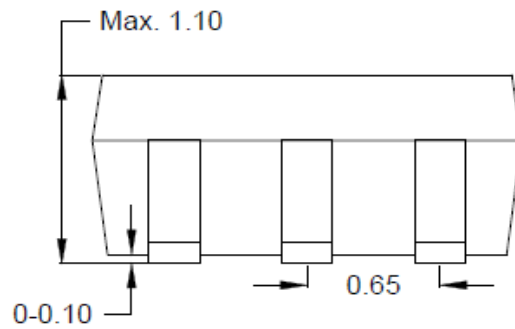
Top Layer

Figure 9. Recommended Layout

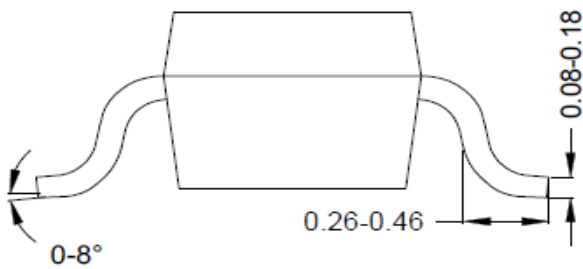
SOT363 Package Outline Drawing



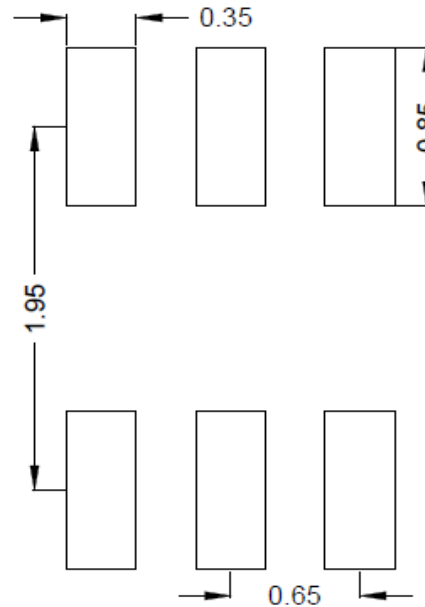
Top view



Side view A



Side view B



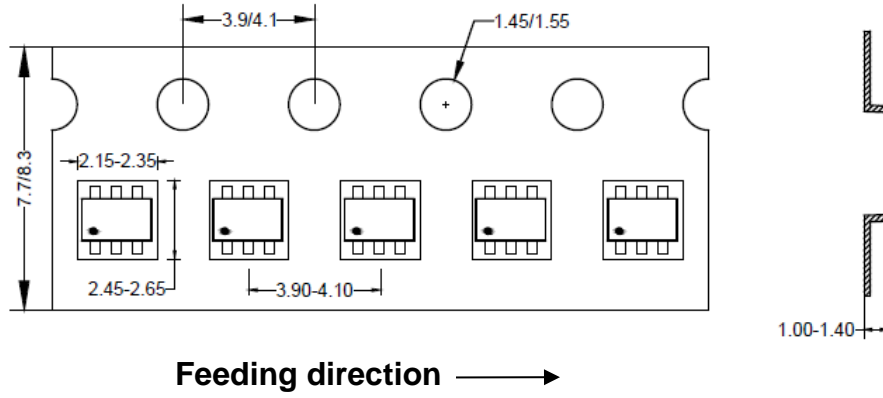
**Recommended PCB layout
(Reference only)**

Notes: All dimension in millimeter and exclude mold flash & metal burr.

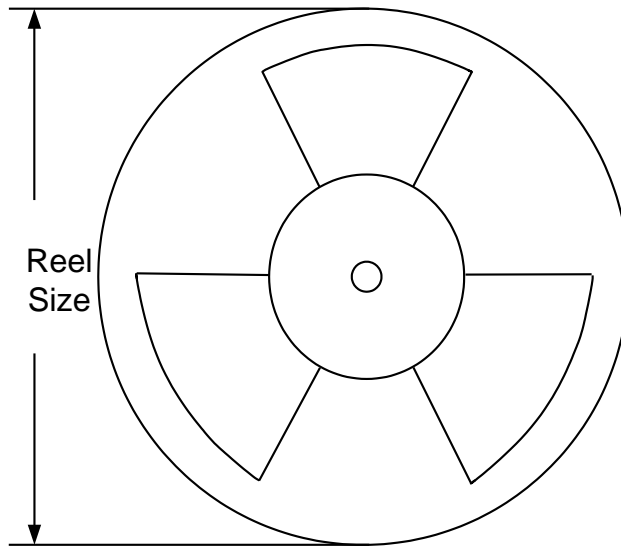
Taping & Reel Specification

1. Tape Dimensions and Pin 1 Orientation

SOT363



2. Reel Dimensions



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
SOT363	8	4	7"	280	160	3000

3. Others: NA

Revision History

The revision history provided is for informational purposes only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
September. 30, 2025	Revision 1.0	Initial Release.

IMPORTANT NOTICE

1. **Right to make changes.** Silergy and its subsidiaries (hereafter Silergy) reserve the right to change any information published in this document, including but not limited to circuitry, specification and/or product design, manufacturing or descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to Silergy's standard terms and conditions of sale.
2. **Applications.** Application examples that are described herein for any of these products are for illustrative purposes only. Silergy makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification. Buyers are responsible for the design and operation of their applications and products using Silergy products. Silergy or its subsidiaries assume no liability for any application assistance or designs of customer products. It is customer's sole responsibility to determine whether the Silergy product is suitable and fit for the customer's applications and products planned. To minimize the risks associated with customer's products and applications, customer should provide adequate design and operating safeguards. Customer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Silergy assumes no liability related to any default, damage, costs or problem in the customer's applications or products, or the application or use by customer's third-party buyers. Customer will fully indemnify Silergy, its subsidiaries, and their representatives against any damages arising out of the use of any Silergy components in safety-critical applications. It is also buyers' sole responsibility to warrant and guarantee that any intellectual property rights of a third party are not infringed upon when integrating Silergy products into any application. Silergy assumes no responsibility for any said applications or for any use of any circuitry other than circuitry entirely embodied in a Silergy product.
3. **Limited warranty and liability.** Information furnished by Silergy in this document is believed to be accurate and reliable. However, Silergy makes no representation or warranty, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. In no event shall Silergy be liable for any indirect, incidental, punitive, special or consequential damages, including but not limited to lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges, whether or not such damages are based on tort or negligence, warranty, breach of contract or any other legal theory. Notwithstanding any damages that customer might incur for any reason whatsoever, Silergy' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Standard Terms and Conditions of Sale of Silergy.
4. **Suitability for use.** Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of Silergy components in its applications, notwithstanding any applications-related information or support that may be provided by Silergy. Silergy products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an Silergy product can reasonably be expected to result in personal injury, death or severe property or environmental damage. Silergy assumes no liability for inclusion and/or use of Silergy products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.
5. **Terms and conditions of commercial sale.** Silergy products are sold subject to the standard terms and conditions of commercial sale, as published at <http://www.silergy.com/stdterms>, unless otherwise agreed in a valid written individual agreement specifically agreed to in writing by an authorized officer of Silergy. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. Silergy hereby expressly objects to and denies the application of any customer's general terms and conditions with regard to the purchase of Silergy products by the customer.
6. **No offer to sell or license.** Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights. Silergy makes no representation or warranty that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right. Information published by Silergy regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from Silergy under the patents or other intellectual property of Silergy.

For more information, please visit: www.silergy.com

© 2025 Silergy Corp.

All Rights Reserved.