Bidirectional, Zero-Drift, High or Low Side, Voltage Output, Current Shunt Monitor

1 FEATURES

- **Wide Common-Mode Range: -0.1V to 28V**
- **Input Offset Voltage: ±10μV (TYP)**
- **Accuracy: (TYP)**
  - **±0.07% Gain Error**
  - **±0.3μV/°C Offset Drift**
  - **4.5ppm/°C Gain Drift**
- **Choice of Gains:**
  - **RS199AP: 50 V/V**
  - **RS199BP: 100 V/V**
  - **RS199CP: 200 V/V**
- **Quiescent Current: 97μA (TYP)**
- **Supply Range: 2.7V to 28V**
- **Operating Temperature Range: -40°C to 125°C**
- **Micro SIZE PACKAGES: SC70-6**

2 APPLICATIONS

- **Notebook Computers**
- **Cell Phones**
- **Qi-Compliant Wireless Charging Transmitters**
- **Telecom Equipment**
- **Battery Chargers**
- **Power Management**

3 DESCRIPTIONS

The RS199XP series of voltage-output, current-shunt monitors (also called current-sense amplifiers) are commonly used for overcurrent protection, precision current measurement for system optimization, or in closed-loop feedback circuits. This series of devices can sense drops across shunt resistors at common mode voltages from -0.1V to 28V, independent of the supply voltage. Three fixed gains are available: 50V/V, 100V/V, and 200V/V. The low offset of the zero-drift architecture enables current sensing with maximum drops across the shunt as low as 10mV full-scale.

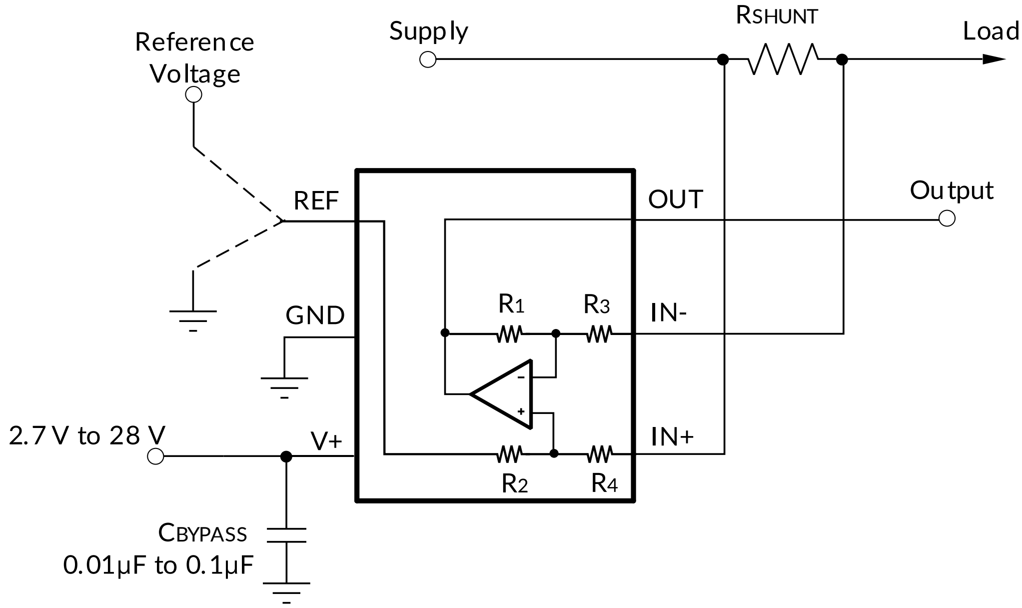
These devices operate from a single 2.7V to 28V power supply, drawing 97μA of supply current. The RS199XP families of operational amplifiers are specified at the full temperature range of -40°C to 125°C, and offered in SC70-6 packages.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS199XP	SC70-6	2.10mm×1.25mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

4 SIMPLIFIED SCHEMATIC



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5 REVISION HISTORY

Note: Page numbers for previous revisions may different from page numbers in the current version.

Version	Change Date	Change Item
A.0	2025/01/03	Preliminary version completed
A.0.1	2025/02/26	Update Electrical Characteristics
A.1	2025/03/27	Initial version completed

6 PACKAGE/ORDERING INFORMATION [1]

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	PACKAGE MARKING [2]	MSL[3]	PACKAGE OPTION
RS199XP	RS199APXC6	-40°C ~125°C	SC70-6 [4]	199AP	MSL3	Tape and Reel,3000
	RS199BPXC6	-40°C ~125°C	SC70-6 [4]	199BP	MSL3	Tape and Reel,3000
	RS199CPXC6	-40°C ~125°C	SC70-6 [4]	199CP	MSL3	Tape and Reel,3000

NOTE:

(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

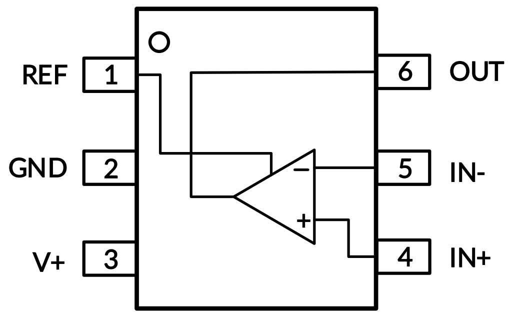
(2) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

(3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F, Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

(4) Equivalent to SOT363.

7 PIN CONFIGURATION AND FUNCTIONS

TOP VIEW



SC70-6

7.1 Pin Description

NAME	PIN	I/O [(1)]	DESCRIPTION
	SC70-6		
REF	1	I	Reference voltage, 0 V to V+
GND	2	-	Ground
V+	3	-	Power supply, 2.7 V to 28 V
IN+	4	I	Connect to supply side of shunt resistor.
IN-	5	I	Connect to load side of shunt resistor.
OUT	6	O	Output voltage

(1) I = Input, O = Output.

7.2 Device Comparison Table

Product	Gain	R_1 & R_2	R_3 & R_4
RS199AP	50	1MΩ	20KΩ
RS199BP	100	1MΩ	10KΩ
RS199CP	200	1MΩ	5KΩ

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) (1)

			MIN	MAX	UNIT
Supply Voltage				30	V
Analog inputs, V_{IN+}, V_{IN-} (2)	Differential (V_{IN+}) - (V_{IN-})		-30	30	
	Common-mode (3)		GND-0.3	30	
Voltage	REF input		GND-0.3	(V+)+0.3	V
	Output (3)		GND-0.3	(V+)+0.3	
Current	Input current Into all pins (3)			5	mA
θ_{JA}	Package thermal impedance (4)	SC70-6		265	°C/W
Temperature	Operating range, T_A		-40	125	°C
	Junction, T_J (5)		-40	150	
	Storage, T_{stg}		-55	150	

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) V_{IN+} and V_{IN-} are the voltages at the IN+ and IN– pins, respectively.
(3) Input voltage at any pin can exceed the voltage shown if the current at that pin is limited to 5 mA.
(4) The package thermal impedance is calculated in accordance with JESD-51.
(5) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.

8.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002 (2)	±1500	

(1) JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250 V CDM allows safe manufacturing with a standard ESD control process.

ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_{CM}	Common-mode input voltage		12		V
V_S	Operating supply voltage (applied to V+)		5		V
T_A	Operating free-air temperature	-40		125	°C

8.4 Electrical Characteristics

(At T_A = 25°C, V_S=5V, V_{IN+}=12V, V_{SENSE}= V_{IN+} - V_{IN-}, V_{REF} = V_S/2, Full [10] =-40°C ~125°C, unless otherwise noted.) [1]

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN[2]	TYP[3]	MAX[2]	UNIT
POWER SUPPLY							
Operating Voltage Range	V_S		FULL	2.7		28	V
Quiescent Current	I_Q	V_{SENSE}= 0mV	25°C		97	150	µA
			FULL			170	
INPUT CHARACTERISTICS							
Input Offset Voltage, RTI [4]	V_{OS}	V_{SENSE}= 0mV	25°C	-120	±10	120	µV
Input Offset Voltage Average Drift	V_{OS} T_C	A Version	FULL	-1	±0.3	1	µV/°C
		B/C Version	FULL	-0.6	±0.2	0.6	
Power-Supply Rejection Ratio	PSRR	V_S=2.7V to 18V, V_{IN+}=18V, V_{REF}=2V, V_{SENSE}= 0mV	25°C	-0.6	±0.2	0.6	µV/V
Input Bias Current [6]	I_B	V_{SENSE}= 0mV	25°C		27	35	µA
Input Offset Current [5]	I_{OS}	V_{SENSE}= 0mV	25°C		±0.03		µA
Common-Mode Voltage Range	V_{CM}		FULL	-0.1		28	V
Common-Mode Rejection Ratio	CMRR	V_{IN+}=-0.1V to 28V V_{SENSE}= 0mV	25°C	100	120		dB
NOISE, RTI [4]							
Input Voltage Noise	e_{np-p}	f= 0.1Hz to 10Hz, A Version	25°C		1.6		µV_{PP}
		f= 0.1Hz to 10Hz, B/C Version	25°C		0.8		
Input Voltage Noise Density	e_n	f = 1kHz, A Version	25°C		45		nV/√HZ
		f = 1kHz, B/C Version	25°C		30		
DYNAMIC PERFORMANCE							
Slew Rate [7]	SR	V_{OUT}=4 V_{PP}, A Version	25°C		0.5		V/µs
		V_{OUT}=4 V_{PP}, B Version	25°C		0.3		
		V_{OUT}=4 V_{PP}, C Version	25°C		0.2		
Bandwidth	BW	C_{LOAD} =10pF, A Version	25°C		60		kHz
		C_{LOAD} =10pF, B Version	25°C		50		
		C_{LOAD} =10pF, C Version	25°C		20		
OUTPUT CHARACTERISTICS							
Swing to V+ Power-Supply Rail		R_L = 10kΩ to GND	25°C		(V+)-0.05	(V+)-0.1	V
Swing to GND		R_L = 10kΩ to GND	25°C		(V_{GND})+ 0.005	(V_{GND})+ 0.01	
Short-Circuit Current [8] [9]	I_{SC}	Source	25°C	15	25		mA
		Sink	25°C	13	18		
Gain	G	A Version	25°C		50		V/V
		B Version	25°C		100		
		C Version	25°C		200		
Gain Error			25°C	-0.5	±0.07	0.5	%
Gain Error vs Temperature			FULL		4.5		ppm/°C
Nonlinearity Error		V_{SENSE}=-5 mV to 5 mV	25°C		±0.01		%
Maximum Capacitive Load	C_{LOAD}	No sustained oscillation	25°C		1		nF

NOTE:
(1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.
(4) RTI = Referred-to-input.
(5) This parameter is ensured by design and/or characterization and is not tested in production.
(6) Positive current corresponds to current flowing into the device.
(7) Number specified is the slower of positive and negative slew rates.
(8) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.
(9) Short circuit test is a momentary test
(10) Specified by characterization only.

8.5 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

Performance measured with the RS199AP at T_A = 25°C, V_S = 5 V, V_{IN+} = 12 V, and V_{REF} = V_S / 2 (unless otherwise noted).

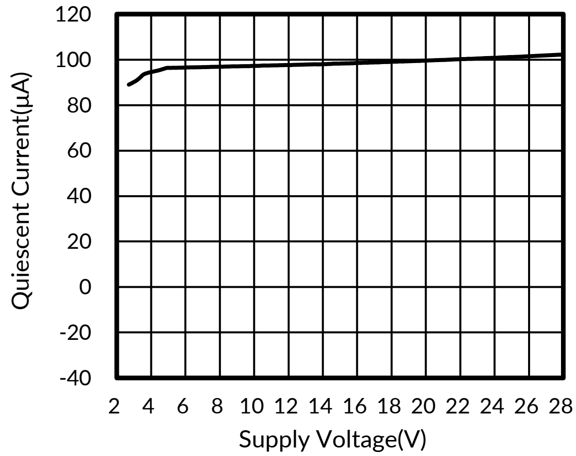


Figure 1. Quiescent Current vs Supply Voltage

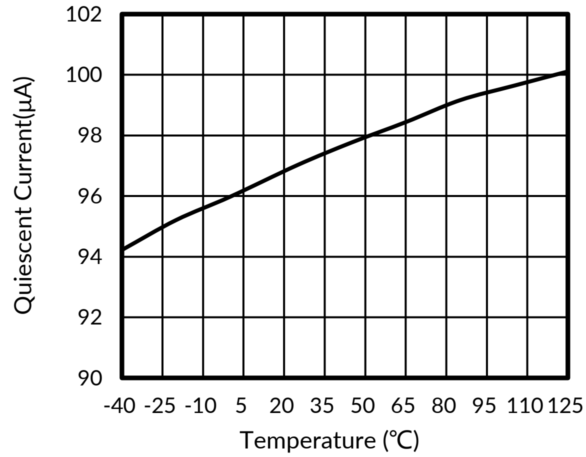


Figure 2. Quiescent Current vs Temperature

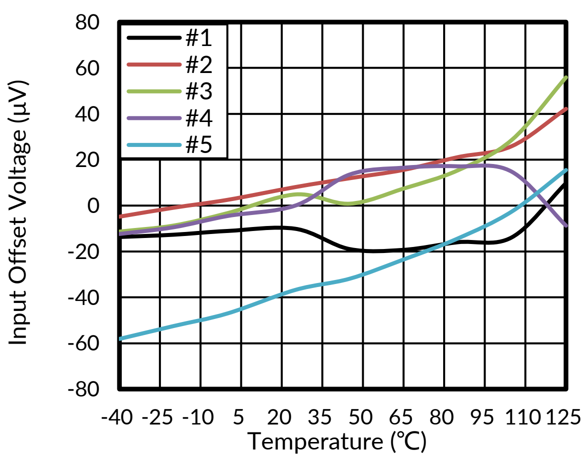


Figure 3. Input Offset Voltage vs Temperature

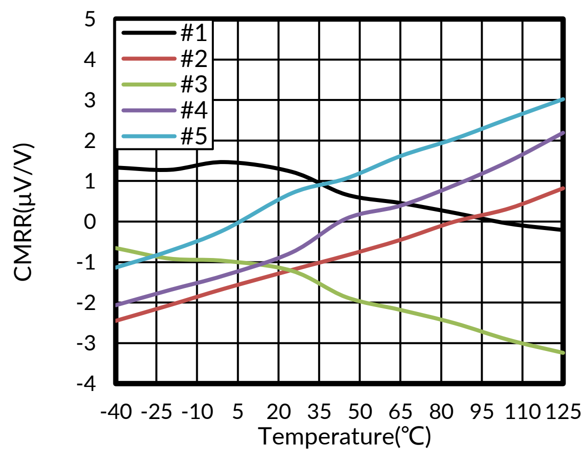


Figure 4. Common-Mode Rejection Ratio vs Temperature

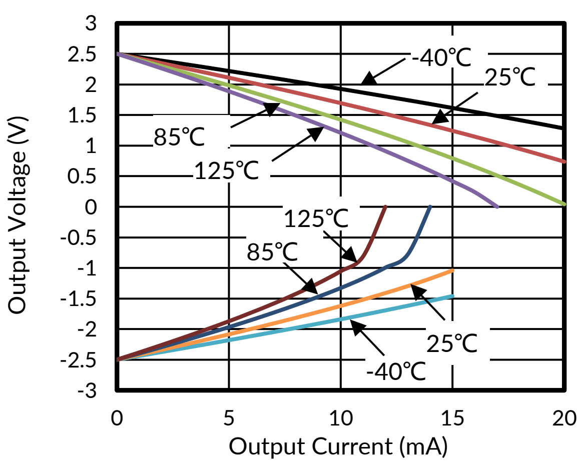


Figure 5. Output Voltage Swing vs Output Current

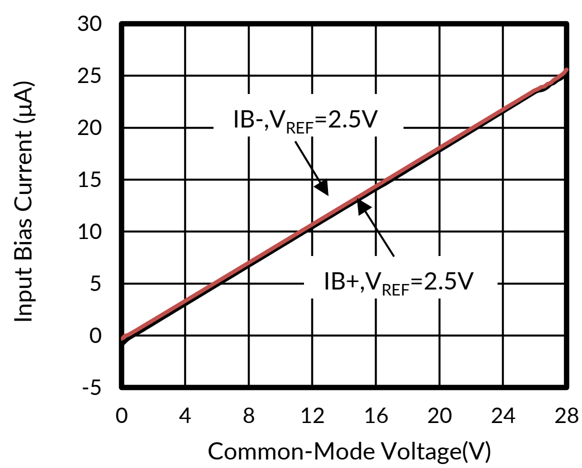


Figure 6. Input Bias Current vs Common-Mode Voltage with Supply Voltage=0V (Shutdown)

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

Performance measured with the RS199AP at T_A = 25°C, V_S = 5 V, V_{IN+} = 12 V, and V_{REF} = V_S / 2 (unless otherwise noted).

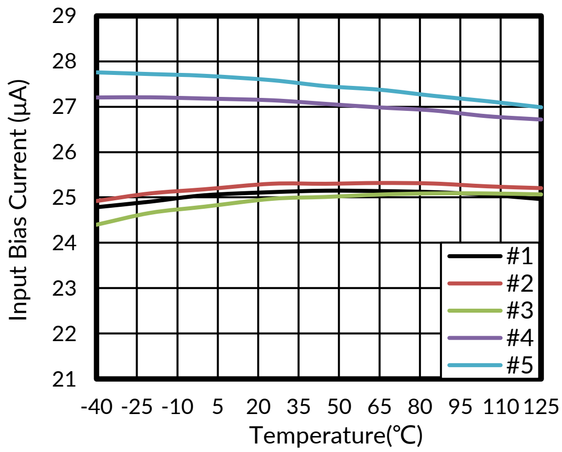


Figure 7. Input Bias Current vs Temperature

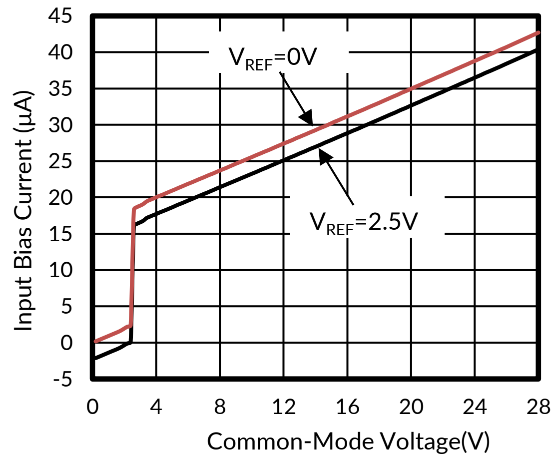


Figure 8. Input Bias Current vs Common-Mode Voltage

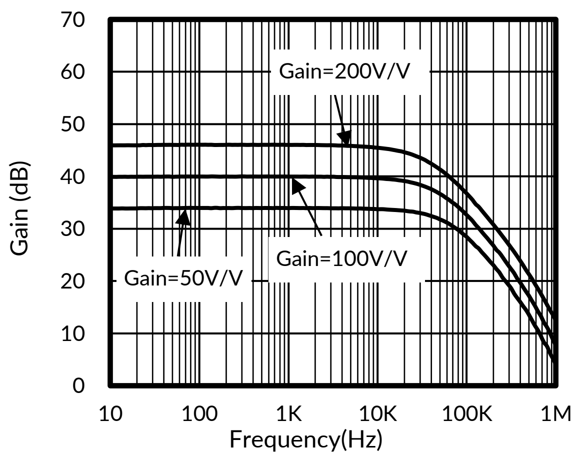


Figure 9. Gain vs Frequency

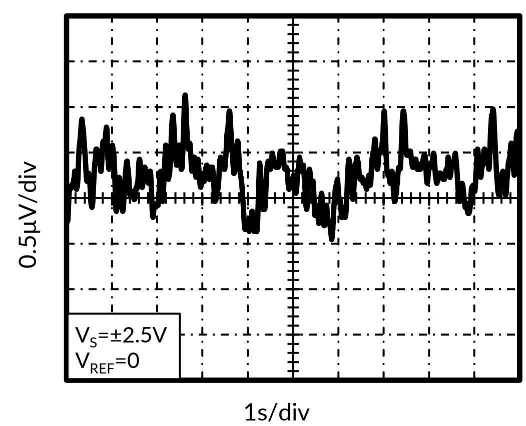


Figure 10. 0.1Hz to 10Hz Input Voltage Noise

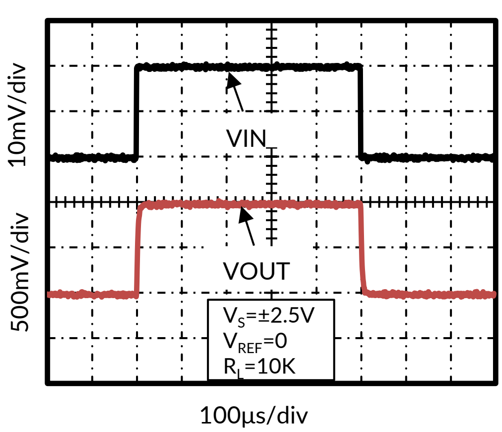


Figure 11. Step Response (20mV$_{PP}$ Input Step)

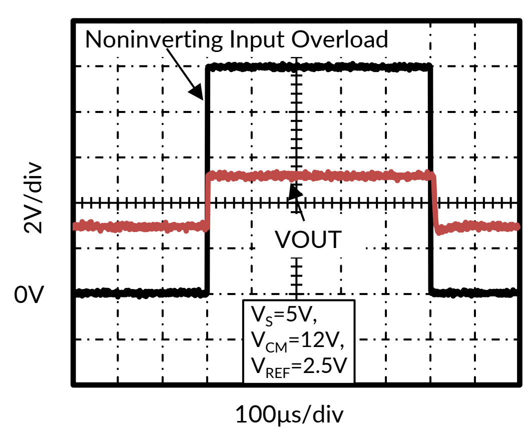


Figure 12. Noninverting Differential Input Overload

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.
Performance measured with the RS199AP at T_A = 25°C, V_S = 5 V, V_{IN+} = 12 V, and V_{REF} = V_S / 2 (unless otherwise noted).

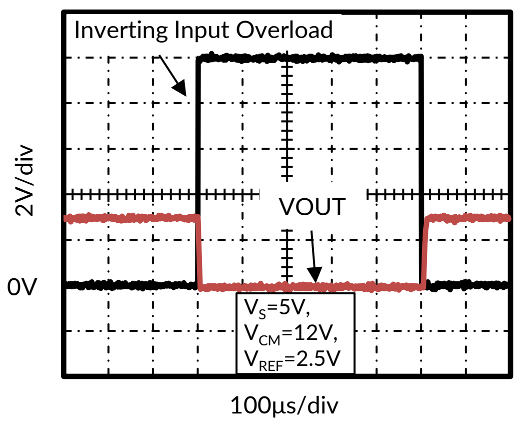


Figure 13. Inverting Differential Input Overload

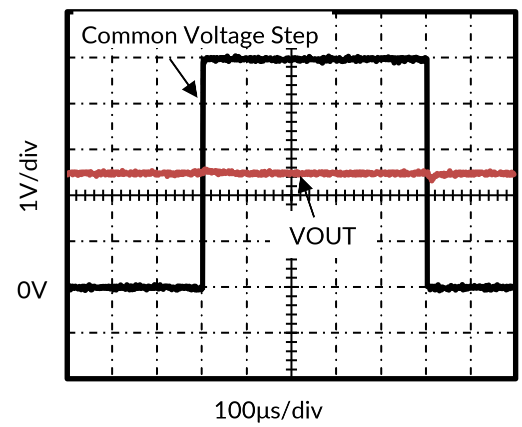


Figure 14. Common-Mode Voltage Transient Response

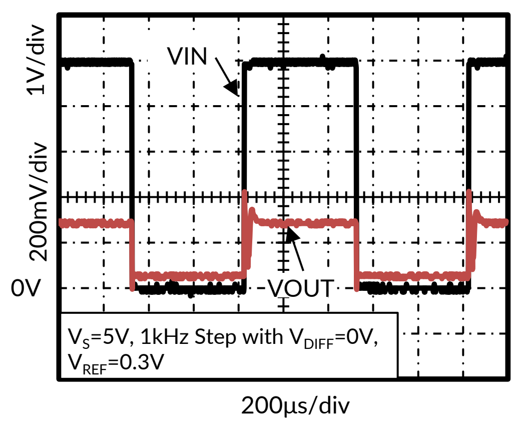


Figure 15. Start-Up Response

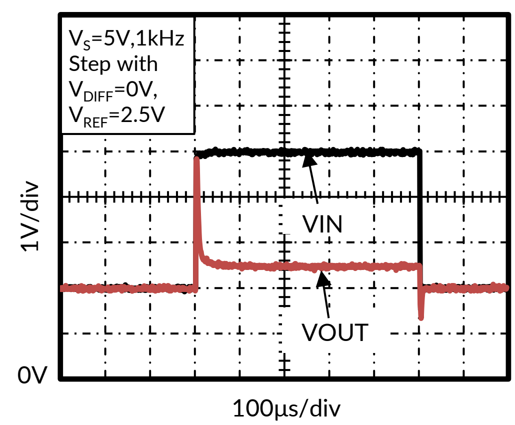


Figure 16. Brownout Recovery

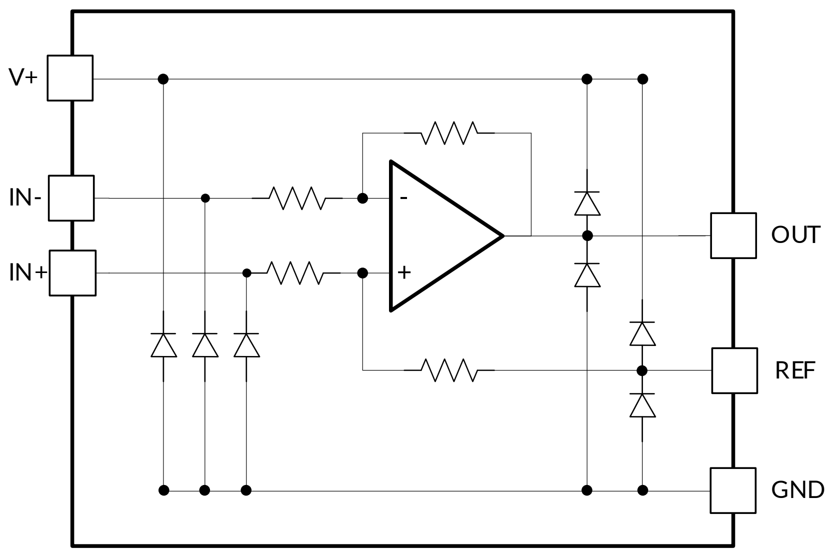
9 DETAILED DESCRIPTION

9.1 Overview

The RS199XP is a 28V common mode, zero-drift topology, current-sensing amplifier that can be used in both low-side and high-side configurations. The device is a specially-designed, current-sensing amplifier that is able to accurately measure voltages developed across a current-sensing resistor on common-mode voltages that far exceed the supply voltage powering the device. Current can be measured on input voltage rails as high as 28V and the device can be powered from supply voltages as low as 2.7V.

The zero-drift topology enables high-precision measurements with TYP input offset voltages as low as 10µV with a maximum temperature contribution of 0.3µV/°C over the full temperature range of -40°C to 125°C.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 Basic Connections

Figure 17 shows the basic connections for the RS199XP. The input pins, IN+ and IN-, must be connected as close as possible to the shunt resistor to minimize any resistance in series with the shunt resistor.

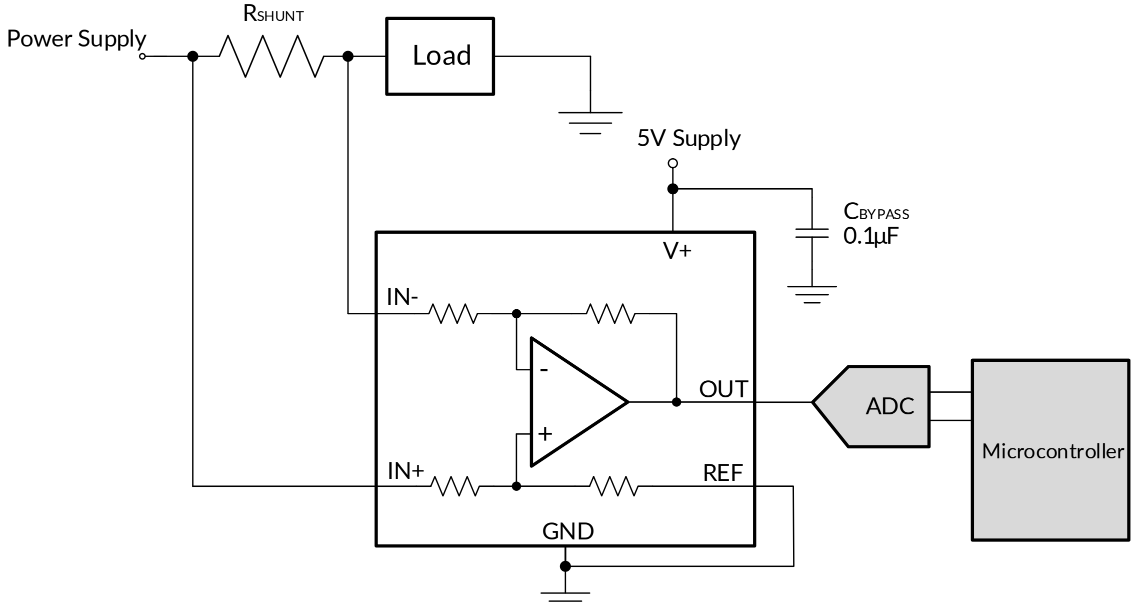


Figure 17. Typical Application

Power-supply bypass capacitors are required for stability. Applications with noisy or high-impedance power supplies may require additional decoupling capacitors to reject power-supply noise. Connect bypass capacitors close to the device pins.

9.3.2 Selecting R_{SHUNT}

The zero-drift offset performance of the RS199XP offers several benefits. Most often, the primary advantage of the low offset characteristic enables lower full-scale drops across the shunt. For example, non-zero-drift current shunt monitors typically require a full-scale range of 100mV.
The RS199XP series gives equivalent accuracy at a full-scale range on the order of 10mV. This accuracy reduces shunt dissipation by an order of magnitude with many additional benefits.
Alternatively, there are applications that must measure current over a wide dynamic range that can take advantage of the low offset on the low end of the measurement. Most often, these applications can use the lower gain of 50 or 100 to accommodate larger shunt drops on the upper end of the scale.

9.4 Device Functional Modes

9.4.1 Input Filtering

An obvious and straightforward filtering location is at the device output. However, this location negates the advantage of the low output impedance of the internal buffer. The only other filtering option is at the device input pins. This location, though, does require consideration of the ±30% tolerance of the internal resistances. Figure 18 shows a filter placed at the inputs pins.

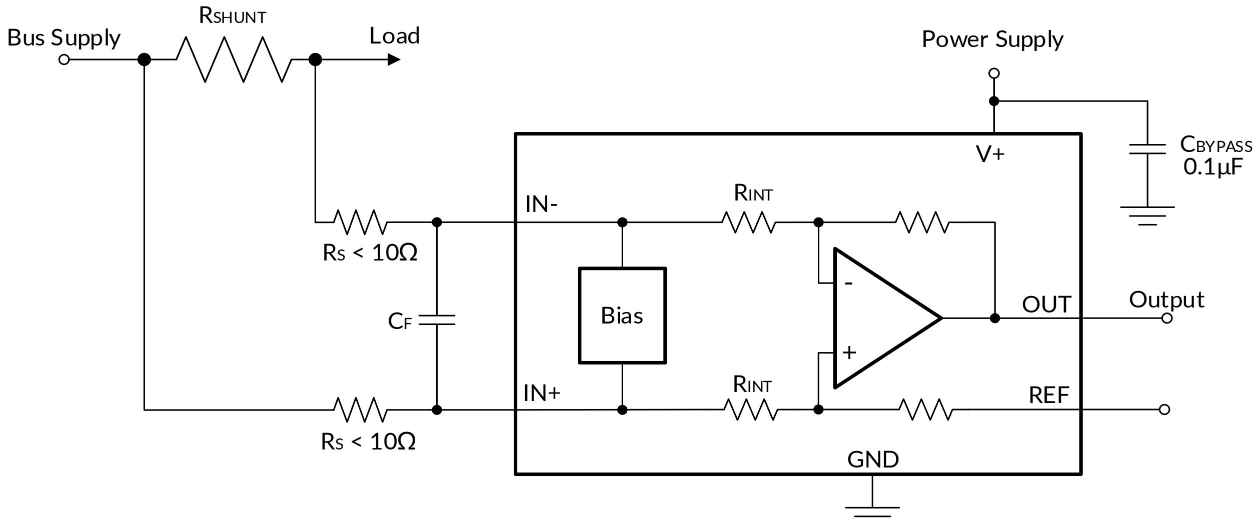


Figure 18. Filter at Input Pins

The addition of external series resistance, however, creates an additional error in the measurement so the value of these series resistors must be kept to 10Ω (or less if possible) to reduce any affect to accuracy. The internal bias network shown in Figure 18 present at the input pins creates a mismatch in input bias currents when a differential voltage is applied between the input pins. If additional external series filter resistors are added to the circuit, the mismatch in bias currents results in a mismatch of voltage drops across the filter resistors. This mismatch creates a differential error voltage that subtracts from the voltage developed at the shunt resistor. This error results in a voltage at the device input pins that is different than the voltage developed across the shunt resistor. Without the additional series resistance, the mismatch in input bias currents has little effect on device operation. The amount of error these external filter resistors add to the measurement can be calculated using Equation 2 where the gain error factor is calculated using Equation 1. The amount of variance in the differential voltage present at the device input relative to the voltage developed at the shunt resistor is based both on the external series resistance value as well as the internal input resistors, R3 and R4 (or R_{INT} as shown in Figure 18). The reduction of the shunt voltage reaching the device input pins appears as a gain error when comparing the output voltage relative to the voltage across the shunt resistor. A factor can be calculated to determine the amount of gain error that is introduced by the addition of external series resistance. The equation used to calculate the expected deviation from the shunt voltage to what is seen at the device input pins is given in Equation 1:

$$\text{Gain Error Factor} = \frac{(1250 \times R_{INT})}{(1250 \times R_S) + (1250 \times R_{INT}) + (R_S \times R_{INT})} \quad (1)$$

where:

- R_{INT} is the internal input resistor (R_3 and R_4).
- R_S is the external series resistance.

With the adjustment factor equation including the device internal input resistance, this factor varies with each gain version, as listed in Table 1. Each individual device gain error factor is listed in Table 2.

Table 1. Input Resistance

PRODUCT	GAIN	R_{INT} (kΩ)
RS199AP	50	20
RS199BP	100	10
RS199CP	200	5

Table 2. Device Gain Error Factor

PRODUCT	SIMPLIFIED GAIN ERROR FACTOR
RS199AP	$\frac{20000}{(17\times R_S)+20000}$
RS199BP	$\frac{10000}{(9\times R_S)+10000}$
RS199CP	$\frac{1000}{R_S+1000}$

The gain error that can be expected from the addition of the external series resistors can then be calculated based on Equation 2:

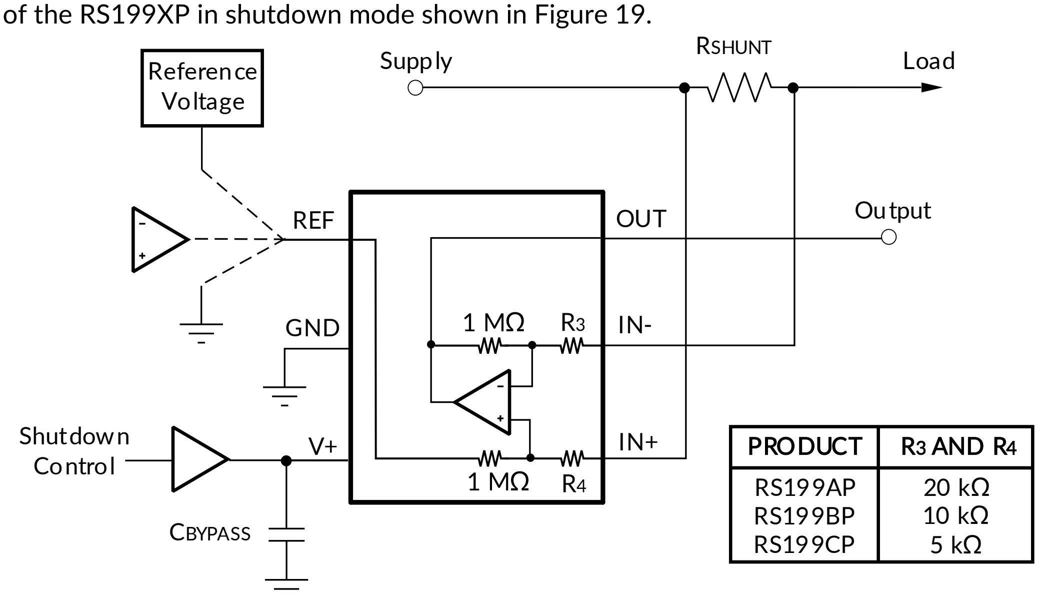
$$\text{Gain Error}(\%)=100-(100\times\text{Gain Error Factor}) \tag{2}$$

For example, using an RS199BP and the corresponding gain error equation from Table 2, a series resistance of 10Ω results in a gain error factor of 0.991. The corresponding gain error is then calculated using Equation 2, resulting in a gain error of approximately 0.89% solely because of the external 10Ω series resistors. Using an RS199XP with the same 10Ω series resistor results in a gain error factor of 0.991 and a gain error of 0.84% again solely because of these external resistors.

9.4.2 Shutting Down the RS199XP Series

Although the RS199XP series does not have a shutdown pin, the low power consumption of the device allows the output of a logic gate or transistor switch to power the RS199XP. This gate or switch turns on and turns off the RS199XP power-supply quiescent current.

However, in current shunt monitoring applications, there is also a concern for how much current is drained from the shunt circuit in shutdown conditions. Evaluating this current drain involves considering the simplified schematic of the RS199XP in shutdown mode shown in Figure 19.



NOTE: 1 MΩ paths from shunt inputs to reference and the RS199XP outputs.

Figure 19. Basic Circuit for Shutting Down the RS199XP With a Grounded Reference

There is typically slightly more than 1MΩ impedance (from the combination of 1MΩ feedback and 5kΩ input resistors) from each input of the RS199XP to the OUT pin and to the REF pin. The amount of current flowing through these pins depends on the respective ultimate connection. For example, if the REF pin is grounded, the calculation of the effect of the 1MΩ impedance from the shunt to ground is straightforward. However, if the reference or operational amplifier is powered when the RS199XP is shut down, the calculation is direct; instead of assuming 1MΩ to ground, however, assume 1MΩ to the reference voltage. If the reference or operational amplifier is also shut down, some knowledge of the reference or operational amplifier output impedance under shutdown conditions is required. For instance, if the reference source functions as an open circuit when not

powered, little or no current flows through the 1MΩ path.
Regarding the 1MΩ path to the output pin, the output stage of a disabled RS199XP does constitute a good path to ground. Consequently, this current is directly proportional to a shunt common-mode voltage impressed across a 1MΩ resistor.

NOTE: When the device is powered up, there is an additional, nearly constant, and well-matched 25µA that flows in each of the inputs as long as the shunt common-mode voltage is 3V or higher. Below 2V common-mode, the only current effects are the result of the 1MΩ resistors.

9.4.3 REF Input Impedance Effects

As with any difference amplifier, the RS199XP series common-mode rejection ratio is affected by any impedance present at the REF input. This concern is not a problem when the REF pin is connected directly to most references or power supplies. When using resistive dividers from the power supply or a reference voltage, the REF pin must be buffered by an operational amplifier.
In systems where the RS199XP output can be sensed differentially, such as by a differential input analog-to-digital converter (ADC) or by using two separate ADC inputs, the effects of external impedance on the REF input can be cancelled. Figure 20 depicts a method of taking the output from the RS199XP by using the REF pin as a reference.

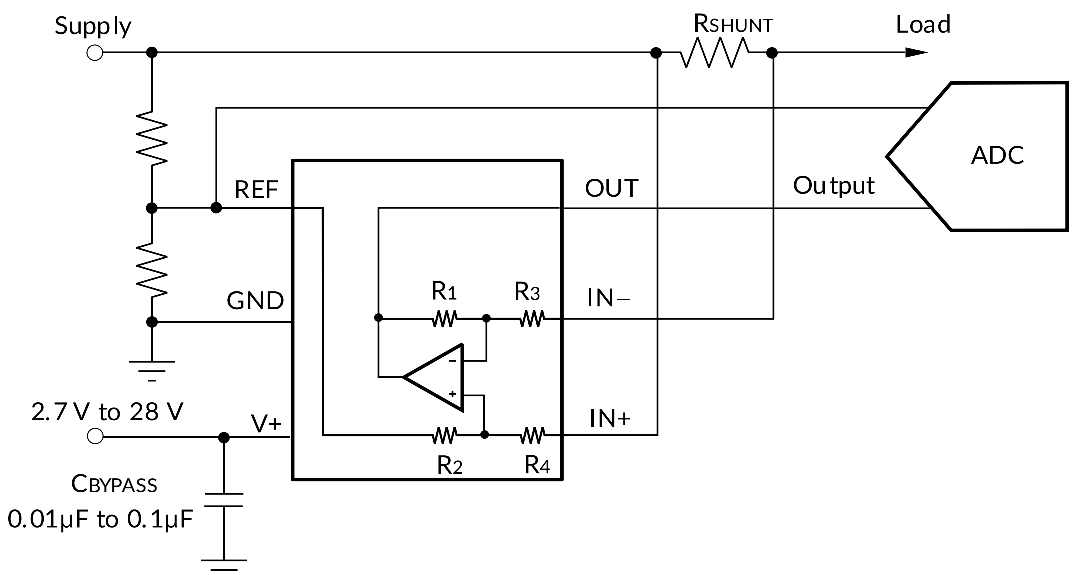


Figure 20. Sensing the RS199XP to Cancel Effects of Impedance on the REF Input

9.4.4 Using the RS199XP With Common-Mode Transients Above 28V

With a small amount of additional circuitry, the RS199XP series can be used in circuits subject to transients higher than 28V, such as automotive applications. Use only Zener diode or Zener-type transient absorbers (sometimes referred to as transzorbs); any other type of transient absorber has an unacceptable time delay. Start by adding a pair of resistors (see Figure 21) as a working impedance for the Zener. Keeping these resistors as small as possible is preferable, most often approximately 10Ω. Larger values can be used with an effect on gain as discussed in the Input Filtering section. Because this circuit limits only short-term transients, many applications are satisfied with a 10Ω resistor along with conventional Zener diodes of the lowest power rating that can be found. This combination uses the least amount of board space.

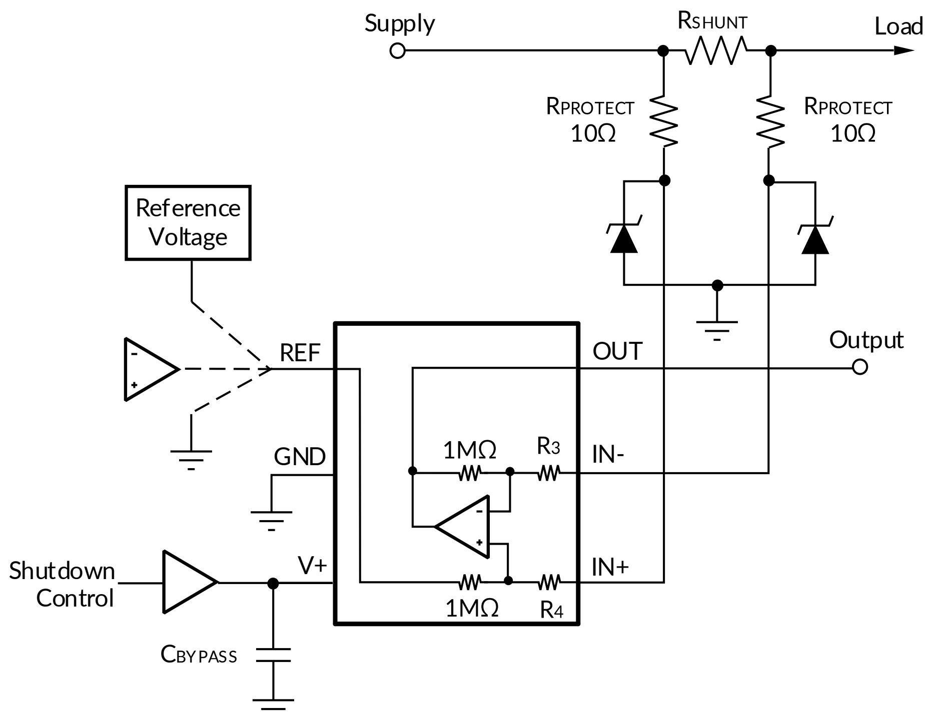


Figure 21. RS199XP Transient Protection Using Dual Zener Diodes

In the event that low-power zeners do not have sufficient transient absorption capability and a higher power transzorb must be used, the most package-efficient solution then involves using a single transzorb and back-to-back diodes between the device inputs. This method is shown in Figure 22.

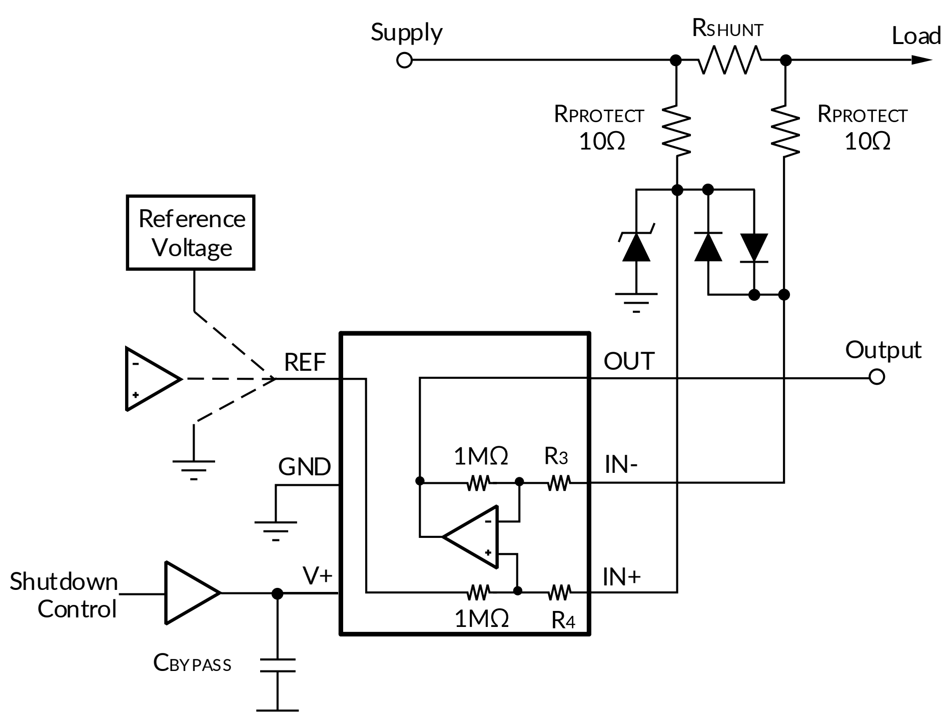


Figure 22. RS199XP Transient Protection Using a Single Transzorb and Input Clamps

9.4.5 Improving Transient Robustness

Applications involving large input transients with excessive dv/dt above 2kV per microsecond present at the device input pins can cause damage to the internal ESD structures on version A devices. This potential damage is a result of the internal latching of the ESD structure to ground when this transient occurs at the input. With significant current available in most current-sensing applications, the large current flowing through the input transient-triggered, ground-shorted ESD structure quickly results in damage to the silicon. External filtering can be used to attenuate the transient signal prior to reaching the inputs to avoid the latching condition. Take care to ensure that external series input resistance does not significantly affect gain error accuracy. For accuracy purposes, keep the resistance under 10Ω if possible. Ferrite beads are recommended for this filter because of their inherently low dc ohmic value. Ferrite beads with less than 10Ω of resistance at dc and over 600Ω of resistance at 100MHz to 200MHz are recommended. The recommended capacitor values for this filter are between 0.01µF and 0.1µF to ensure adequate attenuation in the high-frequency region. This protection scheme is shown in Figure 23.

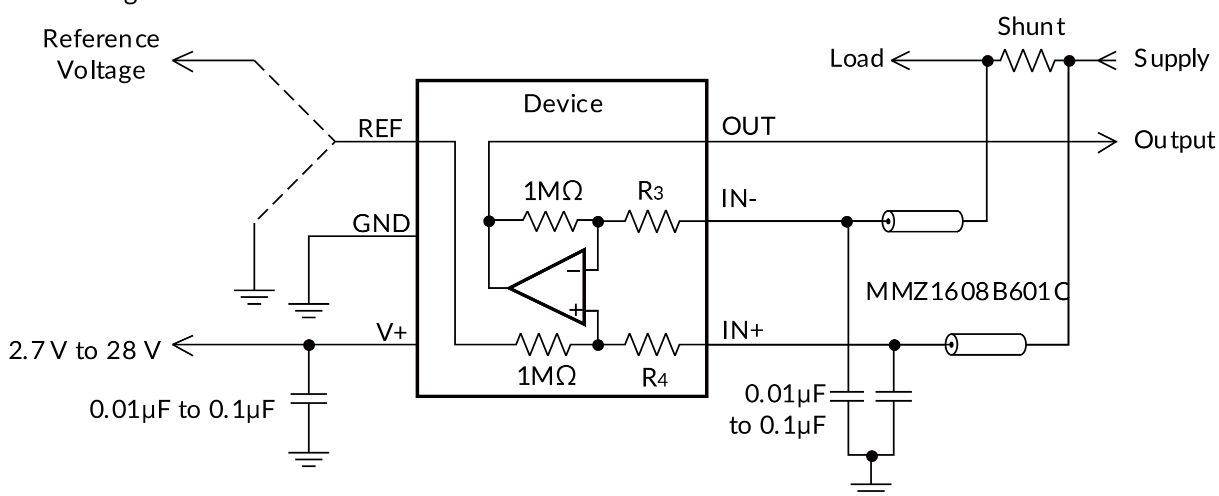


Figure 23. Transient Protection

To minimize the cost of adding these external components to protect the device in applications where large transient signals may be present, version B and C devices are now available with new ESD structures that are not susceptible to this latching condition. Version B and C devices are incapable of sustaining these damages causing latched conditions so these devices do not have the same sensitivity to the transients that the version A devices have, thus making the version B and C devices a better fit for these applications.

10 APPLICATION AND IMPLEMENTATION

Information in the following applications sections is not part of the RUNIC component specification, and RUNIC does not warrant its accuracy or completeness. RUNIC's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

The RS199XP measures the voltage developed across a current-sensing resistor when current passes through it. The ability to drive the reference pin to adjust the functionality of the output signal offers multiple configurations, as discussed throughout this section.

10.2 Typical Applications

10.2.1 Unidirectional Operation

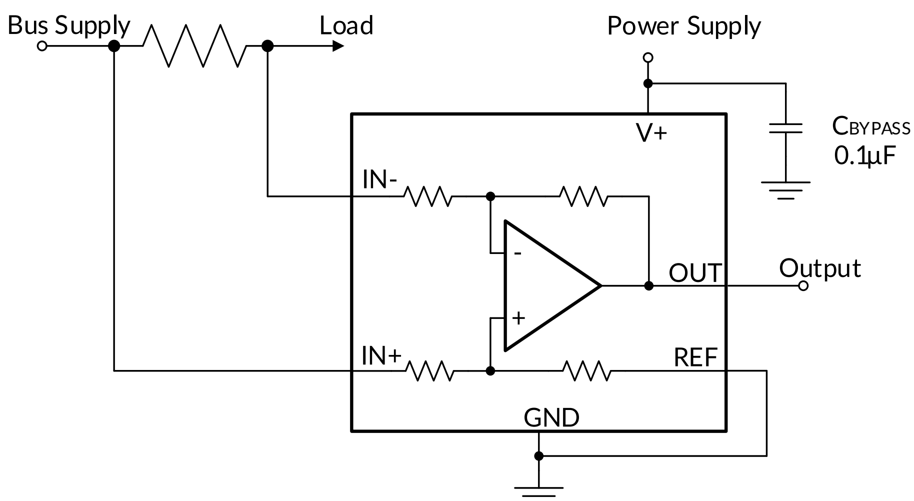


Figure 24. Unidirectional Application Schematic

10.2.2 Design Requirements

The device can be configured to monitor current flowing in one direction (unidirectional) or in both directions (bidirectional) depending on how the REF pin is configured. The most common case is unidirectional where the output is set to ground when no current is flowing by connecting the REF pin to ground, as shown in Figure 24. When the input signal increases, the output voltage at the OUT pin increases.

10.2.3 Detailed Design Procedure

The linear range of the output stage is limited in how close the output voltage can approach ground under zero input conditions. In unidirectional applications where measuring very low input currents is desirable, bias the REF pin to a convenient value above 50mV to get the output into the linear range of the device. To limit common-mode rejection errors, RUNIC recommends buffering the reference voltage connected to the REF pin.

10.2.4 Bidirectional Operation

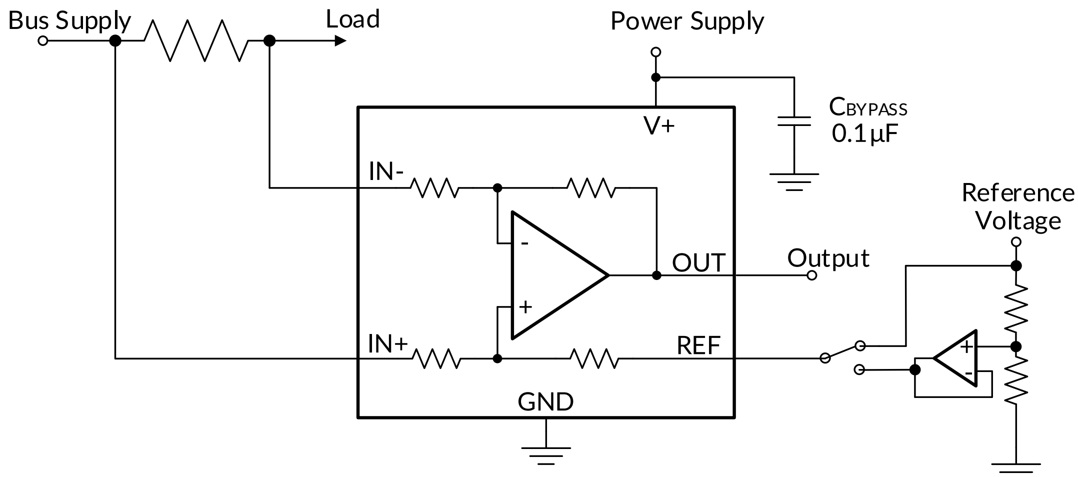


Figure 25. Bidirectional Application Schematic

10.2.5 Design Requirements

The device is a bidirectional, current-sense amplifier capable of measuring currents through a resistive shunt in two directions. This bidirectional monitoring is common in applications that include charging and discharging operations where the current flow-through resistor can change directions.

10.2.6 Detailed Design Procedure

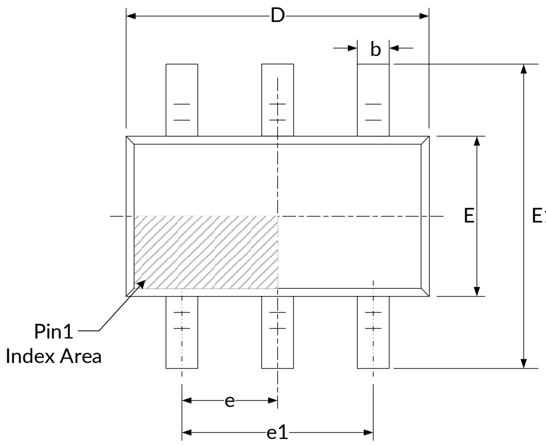
The ability to measure this current flowing in both directions is enabled by applying a voltage to the REF pin; see Figure 25. The voltage applied to REF (V_{REF}) sets the output state that corresponds to the zero-input level state. The output then responds by increasing above V_{REF} for positive differential signals (relative to the IN- pin) and responds by decreasing below V_{REF} for negative differential signals. This reference voltage applied to the REF pin can be set anywhere between 0 V to V+. For bidirectional applications, V_{REF} is typically set at mid-scale for equal signal range in both current directions. In some cases, however, V_{REF} is set at a voltage other than mid-scale when the bidirectional current and corresponding output signal do not need to be symmetrical.

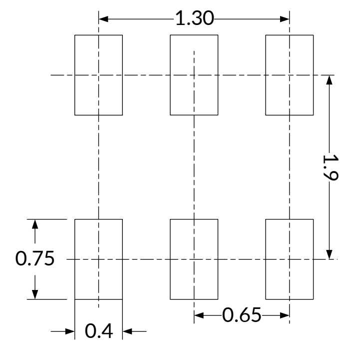
11 POWER SUPPLY RECOMMENDATIONS

The input circuitry of the RS199XP can accurately measure beyond its power-supply voltage, V+. For example, the V+ power supply can be 5V, whereas the load power-supply voltage can be as high as 28V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin. Also, the RS199XP can withstand the full input signal range up to 28V range in the input pins, regardless of whether the device has power applied or not.

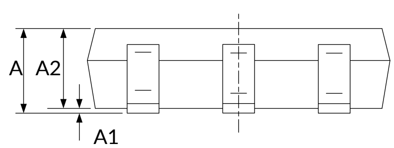
12 PACKAGE OUTLINE DIMENSIONS

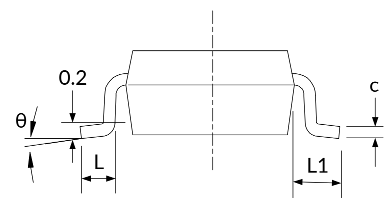
SC70-6 (3)





RECOMMENDED LAND PATTERN (Unit: mm)





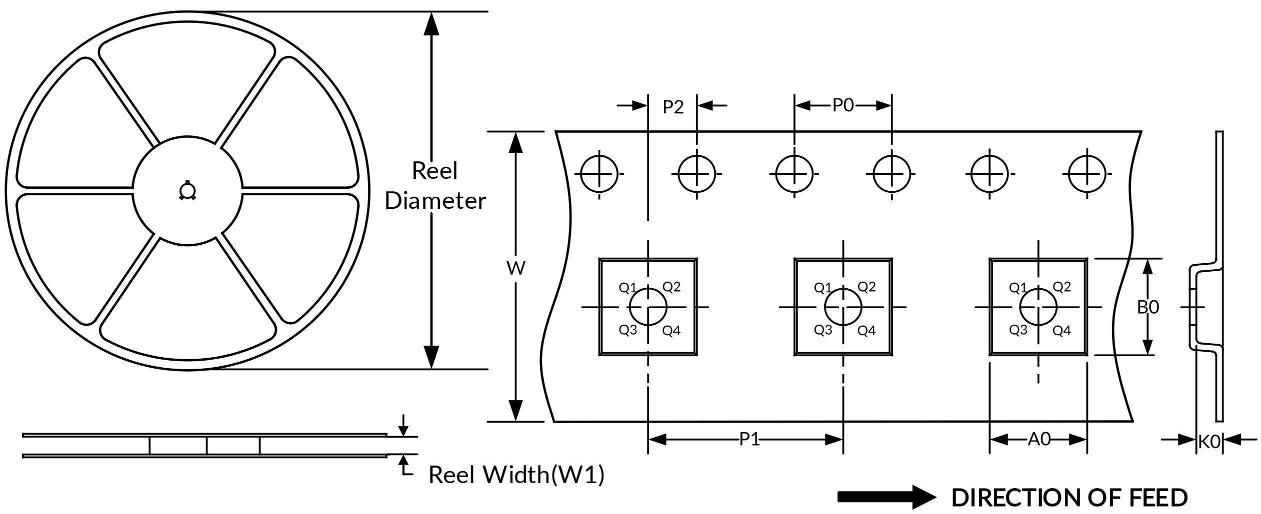
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D (1)	2.000	2.200	0.079	0.087
E (1)	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650 (BSC) (2)		0.026 (BSC) (2)	
e1	1.300 (BSC) (2)		0.051 (BSC) (2)	
L	0.260	0.460	0.010	0.018
L1	0.525		0.021	
θ	0°	8°	0°	8°

NOTE:

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

13 TAPE AND REEL INFORMATION

REEL DIMENSIONS   TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width(mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SC70-6	7’’	9.5	2.40	2.50	1.20	4.0	4.0	2.0	8.0	Q3

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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